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The Federal Plan for Meteorological Services And Supporting Research



FISCAL YEAR 1973

FEDERAL COORDINATOR FOR
METEOROLOGICAL SERVICES
AND SUPPORTING RESEARCH



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Robert M. White

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The Federal Plan for Meteorological Services And Supporting Research

FEDERAL COORDINATOR FOR
METEOROLOGICAL SERVICES AND
SUPPORTING RESEARCH

FISCAL YEAR 1973

January 1972
WASHINGTON, D.C.

Preface

The long-term goal of the Federal Meteorological Services is to **contribute to the health, safety, and welfare of our people and to the efficient use of the environment.** The meteorological activities of all Federal agencies engaged in meteorological services and supporting research are directed toward achieving this goal. In pursuing the goal, benefits are realized that involve the saving of lives, enhancement of the economy, and contributions to the national security. Two alternatives to achieving the goal and benefits are available. They are either to modify the weather or to protect activities that are weather sensitive. While much progress has been achieved in attempts to modify the weather beneficially, improved forecasts are currently the only reliable basis for protection of weather-sensitive activities against the hurricane, tornado, and winter storm. As weather modification technology is developed to an operational capability, a mix of these alternatives will evolve. Regardless of the ultimate mix, the effectiveness of the protective system will be highly dependent upon improvements in the Basic Meteorological Service.

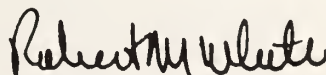
This Federal Plan is the eighth in a series of annual plans developed by the Federal Coordinator for Meteorological Services and Supporting Research. This Plan focuses on the measures being taken to protect weather-sensitive activities. It is published to provide the Congress and the Executive Branch with a coordinated, overall plan for Government meteorological services and for those research and development programs whose immediate objective is to improve meteorological services. The Plan covers the programs of all agencies for FY 1972 and FY 1973. Much of the FY 1973 activity is aimed at strengthening the basic meteorological system through advanced satellites, utilizing larger capacity computers, providing better forecasting models of the ocean and atmosphere that will improve the prediction capability by the last half of this decade, and improving the preparedness of the public to respond to warnings.

Historically, the Federal Plan has provided a description of the Basic and Specialized Meteorological Services and of the various agency plans for improving these Services. These features will continue in this issue of the Plan. Additionally, in response to growing interest and accelerated efforts to meet an expanding need, a special analysis is provided in the area of weather disaster warnings. The Basic Meteorological Service

of the Nation, which provides the fundamental information used by the general public, Federal agencies, and other segments of the economy, may be categorized into two distinct groups: (1) those activities required to provide the routine, day-to-day, scheduled meteorological services; and (2) those additional efforts needed to observe, predict, and provide warnings on severe and devastating storms such as hurricanes and tornadoes. The special analysis on weather disaster warnings is concerned with the second of these groups. All of the agency efforts directed toward weather disaster warnings have contributed significantly to the safety and welfare of our people.

The special analysis on weather disaster warnings is placed at the front of the Plan. This section is followed by a summary of fiscal data for the total services and functions performed. The next section of the Plan provides a description of the Meteorological Services—Basic and Specialized—along with the operational and research programs planned for FY 1973. This section emphasizes the progress made in forecasting services in recent years and provides planning information directed toward improving the Basic Meteorological Service during this decade. Sections follow which treat the changes in operational programs relative to the meteorological functions performed, such as observing weather, transmitting data, preparing forecasts, and disseminating information to users. The final section of the Plan contains a detailed description of the meteorological satellite program. The last page contains a list of publications prepared, or in the process of preparation, by the Federal Coordinator for Meteorological Services and Supporting Research.

The principal work of coordinating weather activities and of preparing and maintaining the Federal Plan is performed by the interagency committees shown on the inside front cover. These committees and their subcommittees conduct systematic, continuous reviews of basic and specialized meteorological requirements, services, and supporting research according to guidelines set forth in the Office of Management and Budget Circular A-62.



ROBERT M. WHITE
Federal Coordinator for
Meteorological Services and
Supporting Research

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Weather Disaster Warning System

INTRODUCTION

Each year severe weather causes property damage amounting to billions of dollars and takes more than 600 lives. During an average year, the U.S. mainland will be threatened by eight tropical storms and will experience 600 tornadoes, more than 600 damaging hailstorms, 800 severe local windstorms, and a dozen east coast winter storms. Destruction of factories and businesses results in additional economic loss from reduced productivity and unemployment. Cooperation among the Federal agencies has resulted in an improved meteorological warning system. This Federal Plan reflects these cooperative efforts directed toward the achievement of effective forecasts and warnings of severe weather which contribute to the economy and security of the Nation.

The need for a system to detect weather hazards and to issue appropriate and timely warnings is well established. For a number of years, Federal agencies have formulated operations plans that call for the cooperative efforts of the agencies to provide detection, prediction, and warning services of severe local thunderstorms and tornadoes, hurricanes, and east coast winter storms. Implementation of these plans has improved the warning and reduced the losses of life and productivity. However, the existing system can be expanded and improved to ensure that all of the people are given accurate and timely alerts and warnings of impending weather disasters. This will permit a more effective response by local communities to impending hazards.

Some individual hurricanes result in more than one billion dollars of damage. Collectively, tornadoes cause more than one billion dollars of damage annually. In a single year, hailfalls account for more than 300 million dollars of damage. Heavy snowfalls on the densely congested east coast are responsible for millions of dollars in losses. Much of the loss from heavy snowfalls could be prevented through improved forecast and warning services. Although little can be done to protect against cata-

strophic damages caused by hurricanes and tornadoes, warning systems can and do minimize the loss of life by triggering protective actions. In the case of hurricanes, warning systems permit the advance preparations for property protection and the reduction in concentration of expensive and weather-sensitive facilities such as aircraft and ships.

Figures 1 and 2 depict the relation over the years between deaths caused by hurricanes and tornadoes and compare them to property losses. The decrease in number of deaths annually can be credited to steady improvements in the warning system. The anomaly noted for hurricane statistics in 1900 represents the 6,000 deaths that resulted from a hurricane that struck Galveston, Tex. The anomalies noted in the 5-year averages for tornado deaths in 1925 and again in 1965 are related to the Tristate tornado (Mo., Ill., and Ind.) of March 18, 1925, that left 689 persons dead, and the Palm Sunday event (Iowa, Wis., Ill., Ind., Mich., and Ohio) of April 11, 1965, in which 272 deaths were recorded. Table 1 illustrates the effectiveness of the warning system and compares results before, during, and after the development of the present system. It is estimated, based upon analyses of public response to warnings such as those issued for the Lubbock, Tex., tornado of May 11, 1970, and the Mississippi Delta tornadoes of February 21, 1971, that several hundred lives are saved yearly by the present system of tornado warnings and an equal number or more are saved because of successful warnings of hurricanes striking congested areas of the U.S. coastline.

While the record indicates that warnings of disastrous weather events and public response to the warnings have improved, the role of the Federal meteorological services in contributing to the national goals of protecting the health, insuring the safety, and preserving the welfare of our people and contributing to the efficient use of the environment needs to be enhanced. The principal effort here is

directed toward a major contribution to safety—the protection afforded and the amelioration of losses resulting from severe weather events. Specifically, the safety objectives are to reduce the error in the 24-hour prediction of hurricane landfall; to provide improved storm-surge predictions associated with hurricanes; to give full service alerts and warnings to at least 90 percent of the population; and to make more precise warnings of the

small short-lived storms, such as severe thunderstorms and tornadoes, and of the longer term crippling snowstorms and ice storms, such as those affecting the densely populated east coast. Figure 3, which shows progress already made in landfall predictions, is an example of what can be accomplished. To accomplish these objectives, the Federal agencies, through their combined efforts, are actively cooperating in three essential areas or thrusts

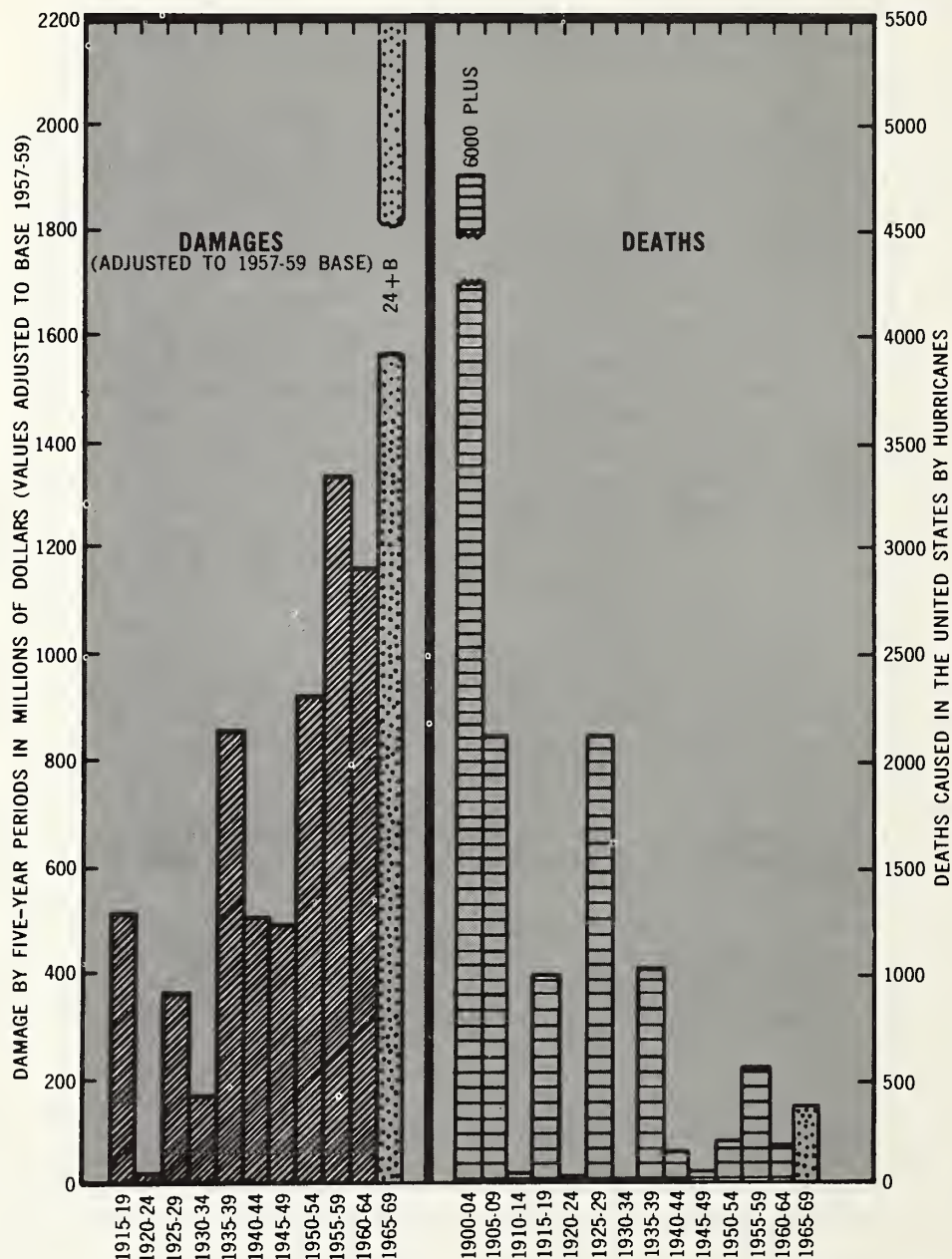


Figure 1. Trends of losses from hurricanes in the United States.

as follows: (1) improving detection and prediction—to reduce forecast errors; (2) speeding up and extending communications for warning the public—to improve timeliness of warnings; and (3) developing community preparedness—to enable more effective use of the weather warning.

Reduction in forecast errors involves the expansion of the radar networks, the acceleration in development of automatic observing stations, the better utilization of information from satellite, the improvement of aircraft reconnaissance, the more effective data analysis and display devices, and the

Table 1. Timely and Accurate Warnings Plus Effective Preparedness Activities do Reduce Deaths from Natural Disasters

HURRICANES

Celia August 1971
30,000 Evacuated
13 Deaths

Audrey June 1957
Little Evacuation
526 Deaths

Galveston 1900
No Preparation
Deaths Exceeded
6,000

Timely and Accurate
Warnings + Community
Preparedness

Timely and Accurate
Warnings Only

No or Poor Warnings
and Preparedness

TORNADOES

Topeka June 8, 1966
17 Deaths

Palm Sunday April 11, 1965
272 Deaths

Tristate March 18, 1925
689 Deaths

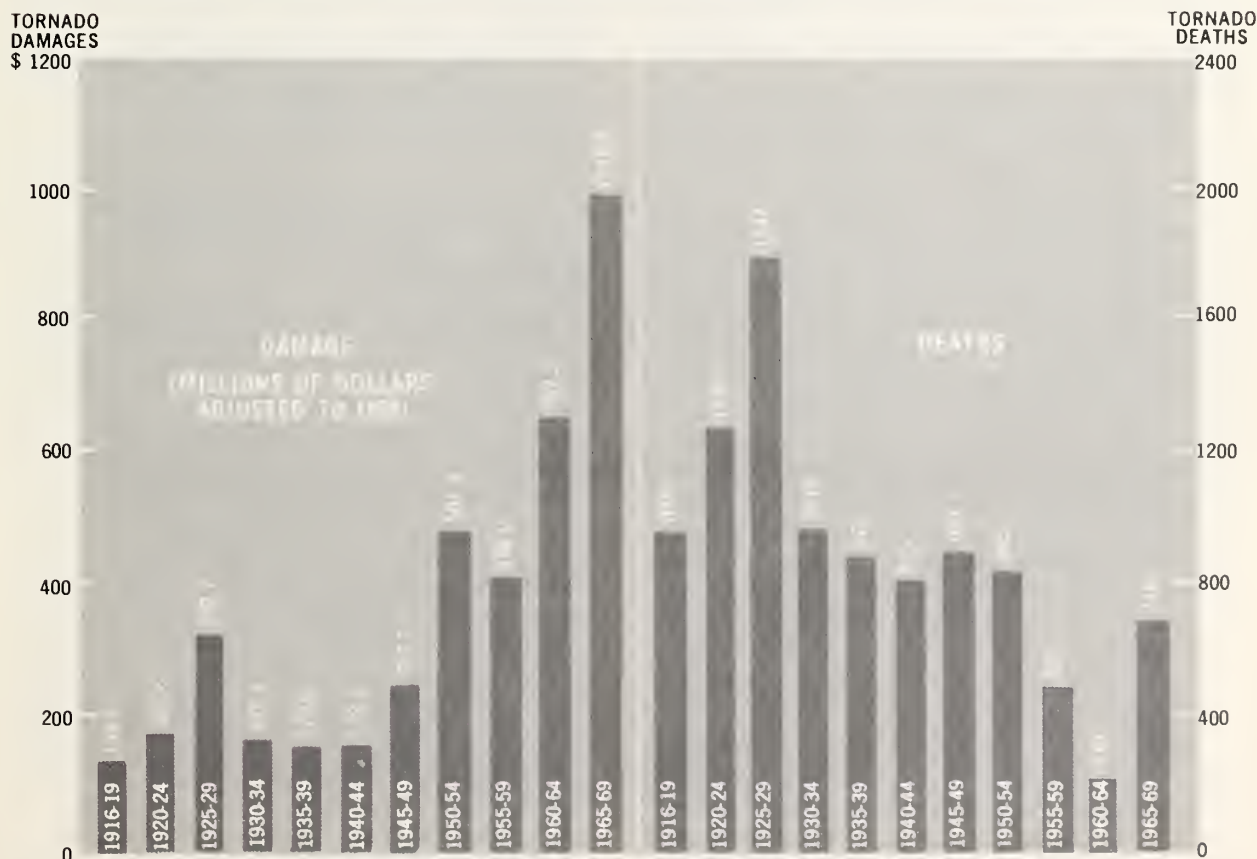


Figure 2. Trends of losses from tornadoes in the United States.



Figure 3. Errors in 24-hour landfall prediction for hurricanes.

intensified research in the short-period weather forecasting. The effort to improve the timeliness of warnings involves the modernization of data acquisition and processing facilities and of communications services needed to insure the rapid preparation and dissemination of warnings. Success of this effort will be dependent upon the use of new observational and computer technology. Finally, to make effective use of the warnings, the users and responsible officials must take positive action upon the receipt of warning information based on well-conceived local disaster plans. This action requires the joint effort of the Office of Emergency Preparedness, State and local Civil Defense officials, and local government officials, stimulated by the meteorological services, to develop appropriate natural disaster warning plans.

The following paragraphs provide a description of the activities by Federal agencies in support of the weather disaster warning system and the planned efforts for Fiscal Year (FY) 1973 directed toward meeting the national goals. Funds reflected in this section are included in the service and functional tables in sections of the Plan that follow.

DESCRIPTION OF WEATHER DISASTER WARNING SERVICE

For purposes of this analysis, weather disaster warning services are concerned with those activities—additional to the activities required to provide the routine, day-to-day scheduled meteorological services—that are needed or primarily used to observe, predict, and provide warnings on severe and devastating storms. These storms are defined in various *Operations Plans* published by the Federal Coordinator for Meteorological Services and Supporting Research.¹ As such, this analysis discusses those services attendant to major storm situations which are potentially hazardous to the general safety, welfare, and economy of the people as a whole. It does not include those weather warning services that are provided specifically for discrete segments of industry such as agriculture, aviation, and marine.

¹ *National Hurricane Operations Plan*, chapter 2.
National Severe Local Storms Operations Plan, section 2.
National East Coast Winter Storms Operations Plan, chapter 2.

The entire structure of weather disaster warning services rests on the foundation of the Basic Meteorological Service which fulfills the many fundamental needs for observations, communications, and analyses and forecasts. Although fundamentally dependent on the Basic Meteorological Service, the needs of a viable weather warning service extend beyond those of a basic service. To meet these needs, certain additional observations, internal and external communications, and specialized analyses and forecasts are superimposed on the Basic Meteorological Service. Weather disaster warning activities also include preparedness planning and specialized research. Although weather radar reporting activities and the Geostationary Operational Environmental Satellite (GOES) spacecraft are elements of the Basic Meteorological Service, the primary mission of these elements is to detect potentially hazardous severe weather for the protection of the public. Consequently, these elements are fundamental parts of the weather disaster warning service system. Similarly, such activities as weather wire services, automatic telephone-answering facilities, and the very high frequency/frequency modulation (VHF/FM) continuous broadcasts serve a routine function of providing daily public service for the basic system. However, their more crucial function is to provide fast and effective dissemination of warning information to the public. These activities are also counted as fundamental parts of the weather disaster warning service system.

DEPARTMENT OF COMMERCE

The objective of the hurricane, tornado, and winter storms weather warning programs is to furnish warnings to the public in sufficient time to enable them to make necessary preparations for safeguarding life and property. The basic observation network of the Department of Commerce is supplemented by special observations from the Cooperative Hurricane Reporting Network (CHURN), various governmental agencies, and foreign governments. Included are observations from U.S. Coast Guard stations and lighthouses; from stations in Mexico, Bermuda, Central America, the West Indies, and the Bahamas; and from amateur radio-reporting networks. There are approximately 145 CHURN stations along the Atlantic and Gulf coasts that have standard weather-measuring equipment furnished by Commerce for obtaining accurate readings of wind speed, wind direction, and barometric pressure. Because most deaths from a hurricane occur as a result of drowning in the storm surge that accompanies the approach of the hurricane center, 27 special tide-gage-reporting fa-

cilities have also been established. The tide-gage readings are remoted to the nearest NOAA National Weather Service (NWS) office and are graphically recorded so that tide heights can be constantly watched and warnings issued when warranted. Critical observational information is obtained for ocean areas from a seasonally maintained Ocean Station Vessel, an experimental ocean buoy, and special reconnaissance flights.

Backup communications are provided by a single sideband radio network of 24 offices along the Gulf and Atlantic east coasts. Standby emergency powerplants are provided at 21 key locations in the hurricane and tornado belt.

Hurricane Warning Preparation

Seven NOAA/NWS offices comprise the core of the Hurricane Warning Service and are responsible for maintaining a close watch on all areas of potential or incipient tropical cyclone formation in their districts and for issuing advisories and bulletins to the general public, disaster and rescue agencies, and salvage workers in threatened areas. The NOAA National Hurricane Center (NHC) at Miami, Fla., is responsible for preparing all analyses of hurricane position and intensity and for forecasting movement and change of intensity. The Hurricane Warning Offices at Boston, Mass., Washington, D.C., New Orleans, La., and San Juan, P.R., after coordination with NHC, are responsible for warnings in their respective areas of responsibility. In accord with international agreements, the Eastern Pacific Hurricane Center at San Francisco, Calif., and the Central Pacific Hurricane Center at Honolulu, Hawaii, provide forecast and warning services over the eastern and central Pacific Ocean similar to those provided by NHC for the Atlantic, Caribbean Sea, and Gulf of Mexico. Hurricane advisories and bulletins prepared by the Warning Offices for the general public and the marine interests contain the position, intensity, direction and rate of movement, and other significant characteristics of the storm. The Department of Defense Joint Typhoon Warning Center on Guam prepares typhoon warnings for the North Pacific west of longitude 180°.

Tornado and Severe Storm Warning Preparation

The NOAA National Severe Storms Forecast Center (NSSFC) at Kansas City, Mo., provides a single source for severe thunderstorm and tornado watches in the United States in support of civil needs. The Center is responsible for the preparation and release of watches that designate areas where the likelihood of severe thunderstorms or tornadoes is high.

All Commerce NWS offices originate tornado warnings to the public on the basis of actual tornado sightings or of radar echo imagery. This information alerts downstream areas of the approaching storm. Local offices recruit and train voluntary severe local storm spotters in cooperation with city, county, and State offices. Observations by these voluntary spotters provide much of the information required to prepare effective and timely warning messages.

Winter Weather Warning Service

With the coming of winter, the NWS annually mounts a concerted effort to detect disturbances that may become severe winter storms and to warn the public as these storms approach.

A special, intensive watch, maintained by the Experimental Regional Warning Coordination Center in New York City, N.Y., in cooperation with several Federal agencies, is being kept on a 150-mile wide strip of the Atlantic along the east coast to detect and to track storms approaching the densely populated coastal region from these offshore waters. Ships, planes, satellites, and an instrumented buoy provide the NWS with the observations needed to issue timely warnings.

Weather Radar

The Synoptic Weather Radar Network, described in greater detail in the subsection of this Plan on Weather Radar Observations, provides continuous imaging of severe weather (e.g., thunderstorms, tornadoes, and approaching hurricanes) throughout the United States. The basic radar of Commerce, the WSR-57, is uniquely capable of imaging severe weather to include the storm's precise location, structure, movement, and intensity—factors needed by meteorologists to prepare and issue weather warnings. Data from all synoptic radars are transmitted to the NSSFC for central analysis and preparation and release of watches. Additionally, the radar data are used locally for immediate and continuous warnings of impending severe weather.

Communications

The Radar Report and Warning Coordination (RAWARC) Teletypewriter Network, to be described in the subsection on Communications, is an internal system for distributing and coordinating storm information. Statewide teletypewriter circuits (NOAA Weather Wire Service—NWWs), also described in the subsection on Communications, expedite the dissemination of consumer-oriented warnings and forecasts to mass news media and to other public and private interests, with complete coverage in 20 States and partial coverage in seven other

States. A high-speed numeric and graphic computer link was established in FY 1971 between the National Meteorological Center/National Environmental Satellite Service (NMC/NESS) of NOAA and the NHC to improve the exchange of aircraft reconnaissance data, satellite data, and processed information. A similar link has been established between the NMC/NESS and the NSSFC.

Community Preparedness

To alleviate preparedness deficiencies in the community and to reduce property damage and loss of life significantly, a program has been started with the objective of informing the public of disaster potential through close cooperation with State and local offices in those communities where these destructive forces of nature are likely to occur. Special community preparedness positions have been established at five Hurricane Warning Offices with funds appropriated in FY 1971.

Dissemination

Hurricane and tornado warnings are given immediate distribution by all available means of communication, but with heavy reliance upon the radio and television broadcasting industry. NOAA weather offices throughout the country provide basic dissemination of hurricane and tornado warnings, with key dissemination nerve centers at the NHC and the NSSFC.

Commerce's NOAA operates a continuous radio weather broadcast service consisting of 61 VHF/FM facilities. This radio service, primarily on the 162.40- and 162.55-MHz bands, provides continuous broadcasts of weather forecasts and warnings and of other pertinent weather information directly from weather offices for use by safety officials, news media, utility companies, or anyone having need for up-to-the-minute information. Through use of a tone-alert device, specially equipped radio receivers can be turned on by the NOAA transmitter, thus providing a positive and immediate notice of warning to anyone having this equipment.

Research

NOAA conducts broad-based programs of basic and applied research and of technique development to provide the basic understanding necessary for developing possible means of lessening the intensity of severe tropical storms and to improve the forecasting and warning services. The research program includes investigation of the structure, circulation, and energy sources of the storm systems, using data obtained by specially instrumented aircraft, meteorological satellites, and conventional weather observational networks. Special studies, using large digital computers for the development

of physically accurate models by simulation of the atmosphere mathematically, are being conducted to provide basic insight into the nature of storm systems. Based on this fundamental work, applied research is carried on to improve the techniques available to the weather forecaster for predicting the formation, motion, intensity, and structure of individual storms. The National Hurricane Research Laboratory (NHRL), located at Miami, is the focal point of the NOAA hurricane research program. The work of NHRL is augmented by research on the mathematical simulation of tropical disturbances conducted in NOAA's Geophysical Fluid Dynamics Laboratory at Princeton, N.J.

The severe local storms research program is centered at the National Severe Storms Laboratory (NSSL), located at Norman, Okla., within the tornado belt. A special severe storms network and an instrumented tower are located in the Oklahoma City, Okla., area. The work of the NSSL is augmented by electromagnetic studies and by development of a Doppler radar system for studying air motions inside and around severe storm systems. The Systems Development Office (SDO) of the NWS is conducting a Digitized Radar Experiment (D/RADEX) to improve identification and prediction of severe local storms. Mini-computers are used to process digitized radar information and present mosaics of storm systems. These techniques permit the quantitative estimates of storm intensities and of precipitation rates. Experiments are also underway to produce composite mosaics of radar and satellite imagery.

Four NOAA research aircraft are Florida-based at the Miami International Airport for operations in the Caribbean hurricane zone and across the Nation. A C-130 and two DC-6 aircraft are specially instrumented as flying laboratories to penetrate hurricanes, to perform cloud-seeding operations, and to obtain meteorological data in the vicinity of tornadoes, squall lines, and other severe local storms. The flight ceiling in gathering meteorological data is about 20,000 feet for the DC-6 aircraft and up to about 35,000 feet for the C-130. A B-57, specially instrumented for meteorological research, is used to obtain meteorological data at elevations between 30,000 and 43,000 feet. All four aircraft are employed year round in research flight activities to provide data needed for weather modification, snowstorm, and other investigations.

DEPARTMENT OF DEFENSE

Severe Weather Warning Forecast Center (SWWFC)

Meeting the military needs for weather warning service is the SWWFC, a branch of the Air Force

Global Weather Central (AFGWC). Located at Offutt AFB, Nebr., the SWWFC provides, by means of a dedicated Defense communication system, tailored severe weather warnings to 600 Defense and Defense-contracted agencies. Severe weather warnings are transmitted in a graphical form. They depict areas within the conterminous United States having the potential to produce weather phenomena which can have a hazardous effect on aircraft and ground operations. In addition, point warnings are provided for a large number of specified locations. These warnings, sent directly to the affected installations by means of defense communications, define the type, intensity, and duration of the expected hazardous weather.

Chief, Aerial Reconnaissance Coordination, Atlantic Hurricanes (CARCAH)

Serving as a liaison between NOAA and the Department of Defense weather reconnaissance units is the CARCAH, who heads a joint U.S. Navy-U.S. Air Force office in Miami. Requests for storm reconnaissance are received in this office from NOAA, and the task is assigned to the reconnaissance unit having resources most readily available to perform the mission. Details as to the functions and procedures of this office are included in the *National Hurricane Operations Plan* and the *National East Coast Winter Storms Operations Plan*.

Aerial Reconnaissance

The Department of Defense performs aircraft reconnaissance flights in support of the various weather warning forecast activities. Atmospheric and oceanographic data obtained from these flights provide the basis for the analysis of the location and physical characteristics of tropical storms in the areas of the Atlantic and Pacific Oceans, Caribbean Sea, and Gulf of Mexico, and of winter storms off the east coast of the United States.

Weather Radar

The Department of Defense employs weather radar for local use purposes in support of its aircraft safety programs and other military operations. A single radar can provide surveillance of weather over an area of more than 70,000 square nautical miles in great detail. These data are particularly suited to the military requirement for issuing warnings in support of aircraft and ground operations. They are essential to the preparation of point warnings for the protection of personnel and installations.

Information from these radars is used primarily to support Defense operations, but this information is also provided to nonmilitary agencies such as the NSSFC.

Warning Services

Within the Department of Defense, weather warnings are issued whenever certain criteria are met. Some examples of the conditions noted in the warnings include hurricanes, tornadoes, high winds, excessive precipitation, and high seas. The criteria for such warnings will vary with the unit or operation affected.

Research

The U.S. Army is conducting basic research on instability patterns in the Tropics. This research seeks to determine patterns in the Caribbean that produce severe weather and to develop techniques for mapping and analyzing them. Both satellite and radar data are analyzed to determine instability regions. Studies have also been pursued in relating the atmospheric refractive and temperature conditions to the onset of tornado, waterspout, and hail occurrences in southern Florida.

The U.S. Navy conducts specialized applied research and technique development in tropical phenomena, with emphasis on tropical cyclones (typhoons). Efforts are concentrating on such critical problems as improved forecasting of typhoons in the Pacific and of severe weather in the Mediterranean. Ongoing programs to forecast typhoons more accurately in the 1- to 4-day range have been supplemented by a program to predict typhoon movement in the 4- to 7-day range. In the Mediterranean area, the Navy has implemented a program to provide detailed forecasting procedures and warnings for weather features which undergo rapid development. The Environmental Prediction Research Facility at Monterey, Calif., is the Navy's prime research center for these problems. The work of this activity is closely coordinated with the numerical programs of the Fleet Numerical Weather Central and is in response to interests from Defense activities in the Pacific and Mediterranean areas.

An automated, integrated airborne weather reconnaissance system is being developed by the U.S. Air Force. When completed, it will upgrade significantly the storm reconnaissance capability of the WC-130 aircraft of its Air Weather Service. These aircraft, in addition to military requirements, support the hurricane warning service. The system will provide more precise hurricane position data and better meteorological information that will contribute to improved forecasts of hurricane movement. A complementary effort is the development of a storm penetration and analysis radar for the airborne weather reconnaissance system. The Air Force is also investigating Doppler radar techniques to detect areas of strong wind shear which are clues to the identification of severe thunderstorms and damaging windstorms.

DEPARTMENT OF TRANSPORTATION

Observations

Since early 1970, the U.S. Coast Guard has operated ocean weather station Hotel to support the NWS in its goal to improve east coast winter storms forecasts. This station, located 200 miles east-northeast of Norfolk, Va. (latitude 38°N. and longitude 71°W.), is manned from August through March of each year by Coast Guard Cutter *Gresham*, a single-purpose vessel. During April and May, the station is unmanned. During June and July, the *Gresham* maintains a standby posture to occupy the station should a tropical disturbance warrant monitoring. The *Gresham*, with NWS observers onboard, makes synoptic surface and upper air meteorological observations to support severe winter storm and hurricane warning services.

Dissemination

As a part of its statutory responsibility to the Marine Meteorological Service, coastal stations of the Coast Guard furnish observations to the NWS. Visual weather warnings are displayed from 163 of these stations. Additionally, the Coast Guard communication system disseminates weather forecasts and warnings of the NWS to marine interests.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Research

Design and development of the Synchronous Meteorological Satellite (SMS-A) geostationary spacecraft will be completed by NASA and is scheduled for launch in December 1972. This SMS-A will provide a capability for near-continuous viewing of severe storms and cloud cover on 24-hour basis. Experience gained from utilization of data from the Applications Technology Satellite (ATS-3), a NASA research and development geostationary spacecraft, has been invaluable. The ATS-3 has shown how observations from geostationary satellites can be utilized to provide more precise and detailed information on the growth and decay of severe weather conditions. This capability will lead to an increased credibility of the weather disaster warning service and will make the service substantially more effective. The SMS-A is a continuation of efforts by NASA to develop a geostationary satellite system that will provide this information on an operational basis.

Development of the SMS-B will be continued to complete the development of the operational prototype spacecraft for the Geostationary Operational Environmental Satellite (GOES) system of the Department of Commerce.

The GOES system is the projected operational system, derived from the ATS experience, for

near-continuous viewing of weather features. The system will also be utilized for collecting and relaying of meteorological data from remote platforms such as buoys, automatic stations, aircraft, and balloons. Interfacing of the Automatic Meteorological Observation System (AMOS) to GOES will provide atmospheric data from remote ocean areas. GOES will also provide for broadcast of centrally produced products, including advisory and warning bulletins to remote locations. In addition to the warning program, data obtained through the GOES system will be used for all environmental prediction programs.

PLANS FOR FY 1973

The Federal agencies are planning a number of significant actions in FY 1973 to improve in a systematic way the system for warning the public and specific user groups of impending disastrous weather

events. These actions, along with those planned for subsequent years, are designed to achieve the national goal of a more effective weather disaster warning service system by the end of this decade.

Radar and its associated remoting equipment are among the prime facilities used to detect the location, intensity, and velocity of severe storms. The Department of Defense (U.S. Navy) is purchasing three weather radars to replace obsolete sets for \$460,000. Rapid and complete communications are vital to an effective warning system. In this regard, Commerce plans to extend or complete the NWWs in nine States and the District of Columbia for \$395,000.

To bolster its satellite operations in support of the disaster warning system, Commerce plans an expenditure of \$2,603,000 in connection with the implementation of the GOES system.

Summary of Fiscal Data

The following tables summarize fiscal information of the Federal Government. The funds shown are those used to provide meteorological services and supporting research, which has as its immediate objective the improvement of these services. Meteorological activities which are integral to Federal programs in weather modification, water resources, and air-sea interaction are not within the purview of this Plan.

All fiscal data reflected in this Plan for FY 1973 are tentative and appear for planning purposes only. These data do not have executive or legislative approval and do not constitute a commitment by the U.S. Government.

The fiscal information is presented by agency and by service and shows FY 1972 data, planned activities for FY 1973, and the net differences for meteorological operations and for supporting research in the accompanying tables.

In FY 1973, supporting research programs amount to \$93,826,000, representing 50 percent of the total Federal expenditure of \$187,532,000 planned for meteorological research as reported to

the Interdepartmental Committee for Atmospheric Sciences of the Federal Council for Science and Technology. Supporting research costs for FY 1973 reflect an increase of \$17,120,000 above FY 1972 largely accounted for by the increase of \$18,728,000 within NASA with significant decreases noted in Defense. The bulk of the NASA increase is for further development of the Nimbus E and F flight programs and the initiation of the TIROS N flight program. The Nimbus E spacecraft is scheduled for launch in November 1972 and Nimbus F in June 1974. These flight programs were approved by the Congress in FY 1969. The experiments planned for the flight programs are indicated in the table at the end of this Plan.

In FY 1973, operational programs amount to \$397,052,000. The funding change for operations from FY 1972 to FY 1973 shows a net increase of \$12,498,000. The decrease of \$6,047,000 in the Department of Defense is a reflection generally of the curtailment of military activities. While the military weather reconnaissance program is being reduced, the funds thus saved are largely offset by

DISTRIBUTION OF OPERATIONAL COSTS, CONTERMINOUS STATES AND OVERSEAS, BY AGENCY

	FY 72		FY 73	
	States	Overseas	States	Overseas
Commerce.....	123,832	10,342	139,913	10,526
Defense:.....	(104,783)	(87,250)	(102,296)	(83,690)
Army.....	3,051	5,694	2,557	3,556
Navy.....	12,663	22,176	13,370	22,556
Air Force.....	89,069	59,380	86,369	57,578
Transportation:.....	(39,319)	(15,317)	(39,534)	(16,736)
Coast Guard.....	472	11,708	633	12,700
FAA.....	38,847	3,609	38,901	4,036
EPA.....	865		1,300	
AEC.....	1,358		1,391	
NASA.....	1,488		1,666	
Total.....	271,645	112,909	286,100	110,952

aircraft modification to improve the reconnaissance capability. The Department of Commerce increase of \$16,265,000 provides for extensive automation of observing facilities, automation and expansion of analyses and prediction services, expansion of weather-warning capabilities, and a major effort toward maintenance and replacement of capital equipment and facilities.

The U.S. Coast Guard provides the ships for seven ocean weather stations in the Atlantic and

Pacific Oceans. Ocean weather station Victor in the Pacific was disestablished in January 1972 to meet personnel and budget limitations. The funds saved by this action are not reflected in this Plan.

Military funds are combined, where appropriate, with civilian funds to show the total Federal expenditure for each category of service. The Department of Defense, like the civilian agencies, funds Basic, Aviation, Marine, Space Operations, and Other Specialized Meteorological Services.

FEDERAL PLAN FOR METEOROLOGICAL OPERATIONS AND SUPPORTING RESEARCH, BY SERVICE

	Operations			Supporting research			Total		
	FY 72	FY 73	Net difference	FY 72	FY 73	Net difference	FY 72	FY 73	Net difference
Basic.....	166,528	186,743	+20,215	50,978	68,491	+17,513	217,506	255,234	+37,728
Aviation.....	156,437	148,128	-8,309	6,613	6,365	-248	163,050	154,493	-8,557
Marine.....	10,395	11,136	+741	643	671	+28	11,038	11,807	+769
Space Operations.....	6,638	9,583	+2,945	2,449	2,664	+215	9,087	12,247	+3,160
Agriculture.....	1,759	2,182	+423	990	1,034	+44	2,749	3,216	+467
General Military.....	29,751	25,307	-4,444	10,432	9,770	-662	40,183	35,077	-5,106
Air Pollution Control....	2,324	3,059	+735	3,657	3,877	+220	5,981	6,936	+955
Other Specialized.....	10,722	10,914	+192	944	954	+10	11,666	11,868	+202
Total.....	384,554	397,052	+12,498	76,706	93,826	+17,120	461,260	490,878	+29,618

FEDERAL PLAN FOR METEOROLOGICAL OPERATIONS AND SUPPORTING RESEARCH, BY AGENCY

	Operations			Supporting research			Total		
	FY 72	FY 73	Net difference	FY 72	FY 73	Net difference	FY 72	FY 73	Net difference
Agriculture.....				820	879	+59	820	879	+59
AEC.....	1,358	1,391	+33	690	700	+10	2,048	2,091	+43
Commerce.....	134,174	150,439	+16,265	4,449	4,384	-65	138,623	154,823	+16,200
Defense:.....	(192,033)	(185,986)	(-6,047)	(15,914)	(14,520)	(-1,394)	(207,947)	(200,506)	(-7,441)
Army.....	8,745	6,113	-2,632	9,164	8,525	-639	17,909	14,638	-3,271
Navy.....	34,839	35,926	+1,087	1,325	1,370	+45	36,164	37,296	+1,132
Air Force.....	148,449	143,947	-4,502	5,425	4,625	-800	153,874	148,572	-5,302
EPA.....	865	1,300	+435	2,925	2,945	+20	3,790	4,245	+455
NASA.....	1,488	1,666	+178	46,055	64,783	+18,728	47,543	66,449	+18,906
Transportation:.....	(54,636)	(56,270)	(+1,634)	(5,853)	(5,615)	(-238)	(60,489)	(61,885)	(+1,396)
Coast Guard.....	12,180	13,333	+1,153				12,180	13,333	+1,153
FAA.....	42,456	42,937	+481	5,853	5,615	-238	48,309	48,552	+243
Total.....	384,554	397,052	+12,498	76,706	93,826	+17,120	461,260	490,878	+29,618

Another table shows the distribution of operational costs only, by agencies, between the United States and overseas areas. This table clearly illustrates the heavy investment in meteorological services that is required to meet military needs outside the conterminous States. Certain funds, such as those for weather reconnaissance and some contracts for missile range support, are included in the States category because funds are contracted for or reported by the parent unit within the United States, although the operations actually may be performed in overseas areas.

The last table in this section shows the extent to which Federal agencies are making use of each other's capabilities through the purchase of meteorological services and/or supporting research by inter-agency fund transfers in FY 1972.

Funds used throughout this Plan represent the total obligational authority required for each year and are presented by Fiscal Year. Funds are given in thousands of dollars on all tables.

INTERAGENCY FUND TRANSFERS FOR METEOROLOGICAL OPERATIONS AND SUPPORTING RESEARCH, FY 1972

Funds transferred from	Funds transferred to	
	Operations	Research
Army.....	Commerce	200
Navy.....	Commerce	900
	Agriculture	50
	Federal Communi- cations	40
	Commission Coast Guard	40
Air Force.....	Commerce	52
	FAA	1
Commerce.....	NASA	18,065
FAA.....	Alaskan Com- munications System	27
		AEC 185 Commerce 776 Navy 380
EPA.....	Commerce	865
AEC.....	Commerce	1,106
NASA.....	Air Force	64
	Commerce	1,152
		Commerce 740 Commerce 530

Meteorological Services

INTRODUCTION

Collectively, the general public, national defense, and specialized elements of the economy require weather information to support their daily activities effectively and to plan for their future actions. Many needs can be fulfilled by a basic service, but some require specialized applications. Two types of Meteorological Services—Basic and Specialized—are provided by Federal agencies. The Basic Meteorological Service of the United States meets the need of the general public, fulfills those requirements that are common to two or more agencies, and provides the foundation for disaster warnings and the Specialized Meteorological Services. This Basic Service is used by all Government agencies in rendering services assigned as their mission.

The Specialized Meteorological Services provide the facilities, products, and distribution mechanisms necessary to serve the specific user groups. These Services include those designed for aviation, marine, space operations, agriculture, general military, air pollution control, and others.

During the past 20 years, the ability to predict various weather elements has improved significantly. In 1955, the Departments of Defense and Commerce joined forces to take advantage of developing computer technology and organized the Joint Numerical Weather Prediction (JNWP) facility. Figure 4 depicts the forecast skill before the advent of the JNWP and compares it to successively more sophisticated atmospheric prediction models used over the succeeding years. The more effective utilization of available and emerging technologies—satellites, advanced computers, and new models—will result in dramatic improvements in forecasting skill by the end of this decade. A “step” improvement larger than that of block E over D can be anticipated. While this figure shows a comparison of the forecast skill by which general guidance products are prepared at the National Meteorological Center (NMC) of NOAA, it is typical of the improvements made also at the Defense centers. Figures 5 and 6 illustrate the improved

forecast skills achieved over the same time frame at Salt Lake City, Utah, and Chicago, Ill., with respect to temperature forecasting. Such increases in accuracy followed the introduction of more advanced, sophisticated numerical modeling.

An indication of the increases in demand by the general public for weather information services is the steadily increasing demand for weather services as measured by the number of calls received yearly at the automatic distribution system in operation at Washington, D.C. (fig. 7).

Meteorology has an impact on most of man's activities. The most dramatic impact is, of course, the destruction to property and the deaths caused by nature's violent storms. However, the secondary effects and impacts are upon the Nation's economy; the loss of employment and production, measured in millions of dollars, may be staggering. While some economic effects may be direct and quantifiable, there are many second-order effects that cannot be quantified. Additionally, the value of human life and the social value of security cannot be measured in monetary terms. Therefore, the true present value of meteorological services is exceedingly difficult, if not impossible, to determine. Most economic analyses that have been attempted are directed toward a determination of the economic benefits of specialized services. Such analyses have been applied to a limited sample of meteorological data and have used “order-of-magnitude” estimates of weather losses. The most comprehensive review of the overall problem is contained in the book, *The Value of the Weather*.²

To quantify the economic benefits of weather services, it is necessary to consider the optimumization of operating decisions that are achievable with a given state of meteorological knowledge and the scientific advances that reflect improvement in

² Maunders, W.J., 1970, *The Value of the Weather*, Methuen and Co. Ltd., London EC4.

PERFECT
FORECASTS

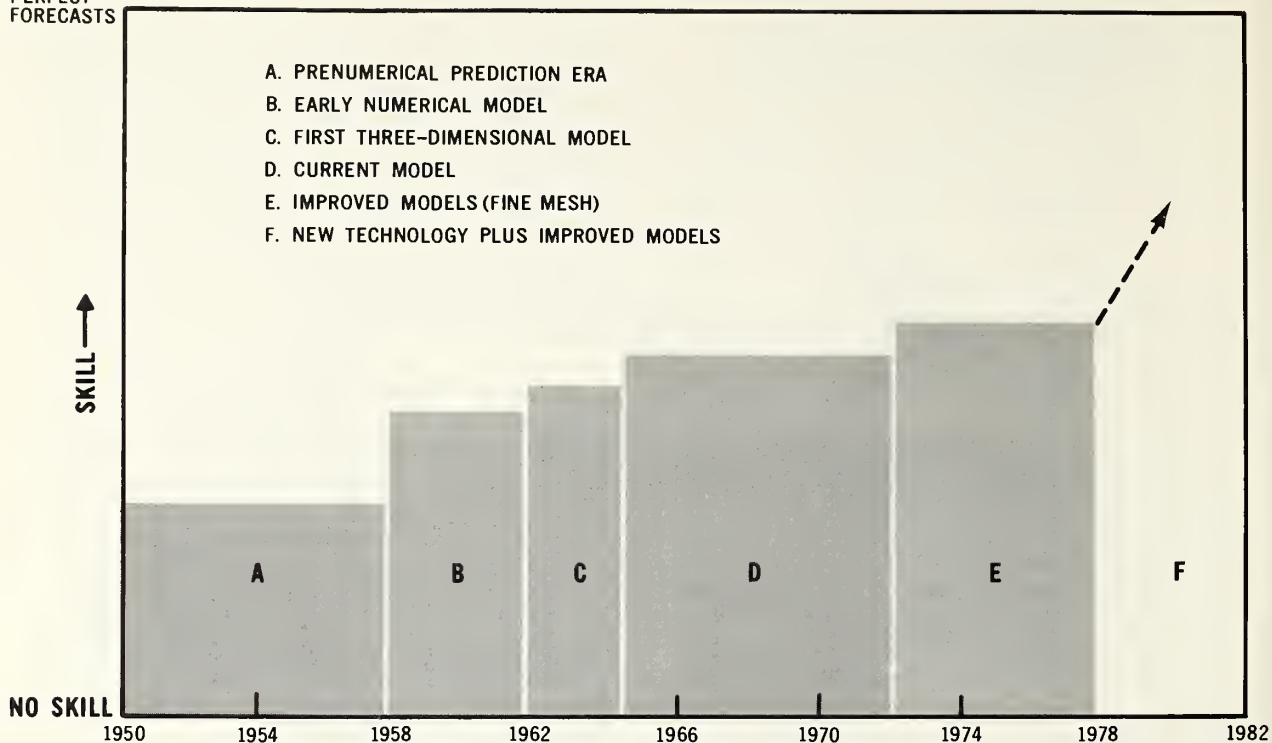


Figure 4. Relative skill for 36-hour predictions by the NMC extended to include anticipated improvements.

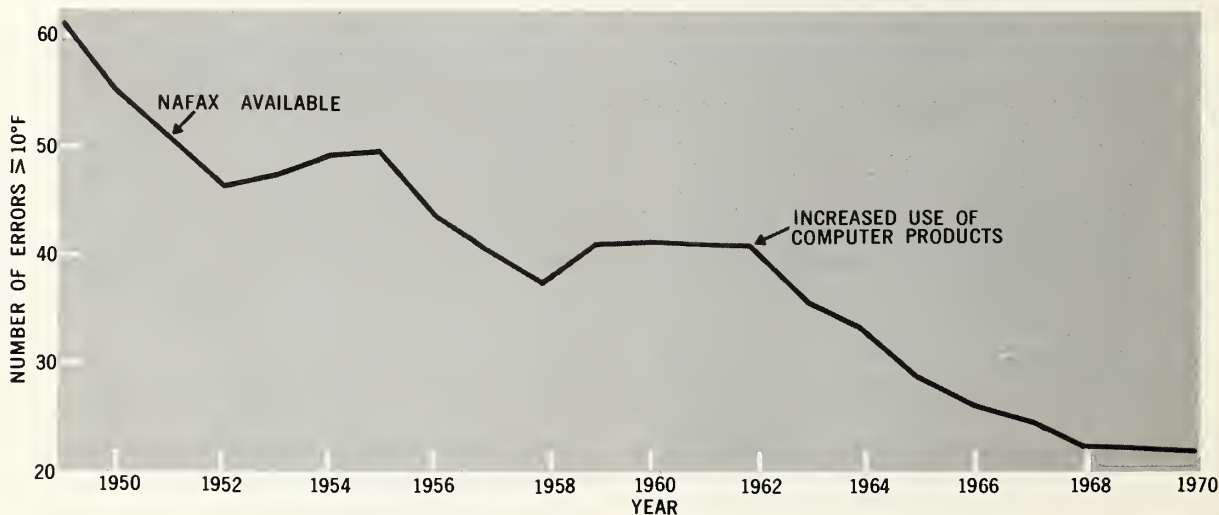


Figure 5. Trend in forecast errors of maximum temperature equal to or greater than 10°F for Salt Lake City, Utah, in 24- to 36-hour forecasts.

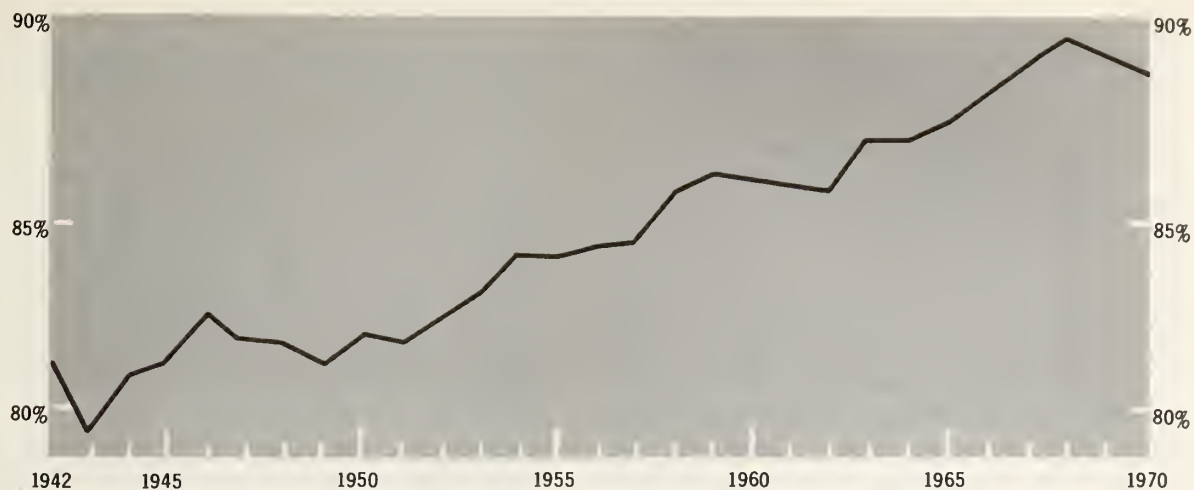


Figure 6. Trend of percentage of correct forecasts for Chicago, Ill. Data are based on two forecasts a day for three 12-hour periods averaged together. Verification is based on

"hit or miss" of 0.01 inch of precipitation and of temperature errors equal to or greater than 10°F each period.

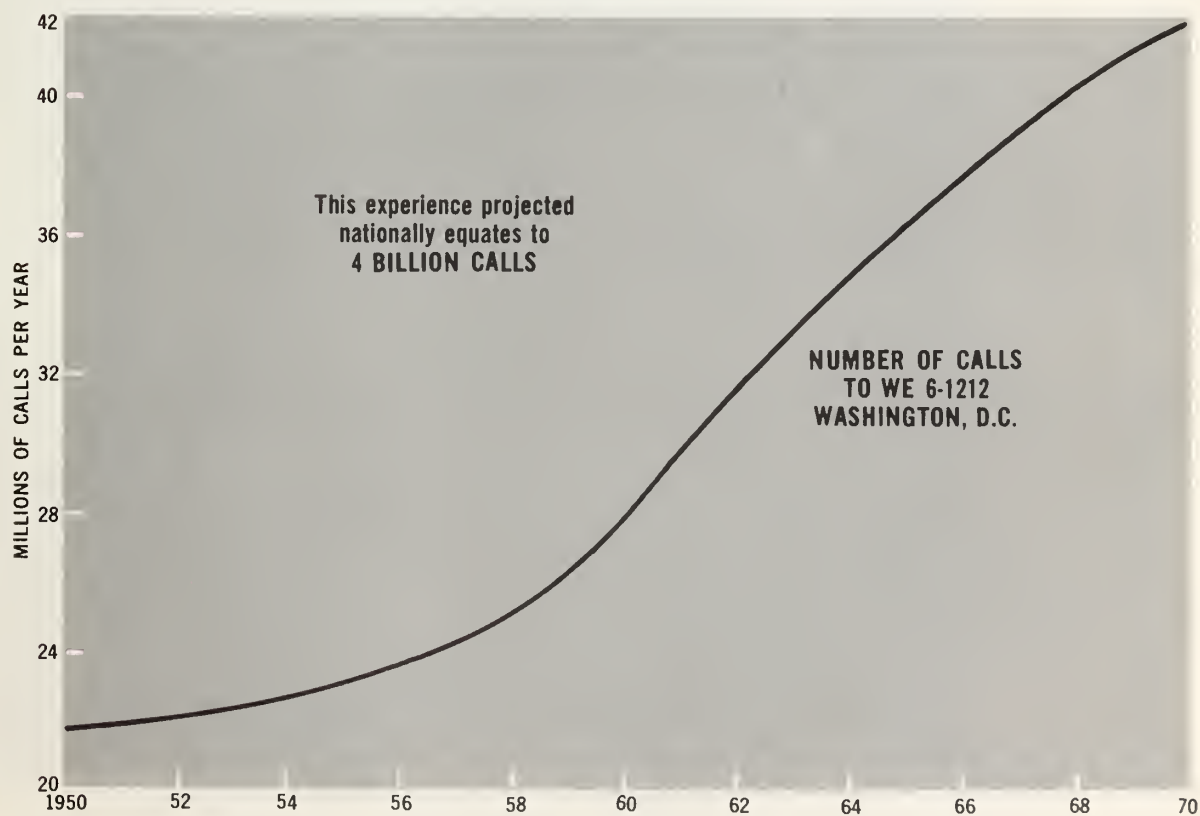


Figure 7. Trend of increasing number of calls each year for weather information and forecasts from the automatic telephone-answering service.

such knowledge. A meteorologic-economic model that considers these factors and provides a means of assessing the magnitude of economic gains has been proposed.³ Although not completely tested, it can be applied to produce an estimate of the economic benefits of the Basic Meteorological Service. More importantly, the model can serve as a basis for the articulation of the benefits of that Service. Reduced to its simplest form, the model is illustrated in figure 8. The "operational" curve indicates the percentage of losses that can be eliminated with today's forecasts. The "scientific advancement" curve indicates the percentage of losses

that could be eliminated not only from improved prediction, but also from better dissemination and better understanding by users.

The sum of these two curves represents the total potential economic gains. Results are provided in terms of the percentage reduction in expenses associated with current protectable weather losses. An estimate of the magnitude of the savings in monetary units can be obtained by applying the percentages to appropriate existing losses caused by weather. It is seen that much benefit remains to be derived—many times that amount spent on the service.

Using the statistics available, it appears that the "order-of-magnitude" estimate of the total annual losses resulting from weather in the United States is

³ Thompson, J.C., 1969, "The Value of Weather Forecasts," *Science Journal*, December 1969, pp. 62-66.

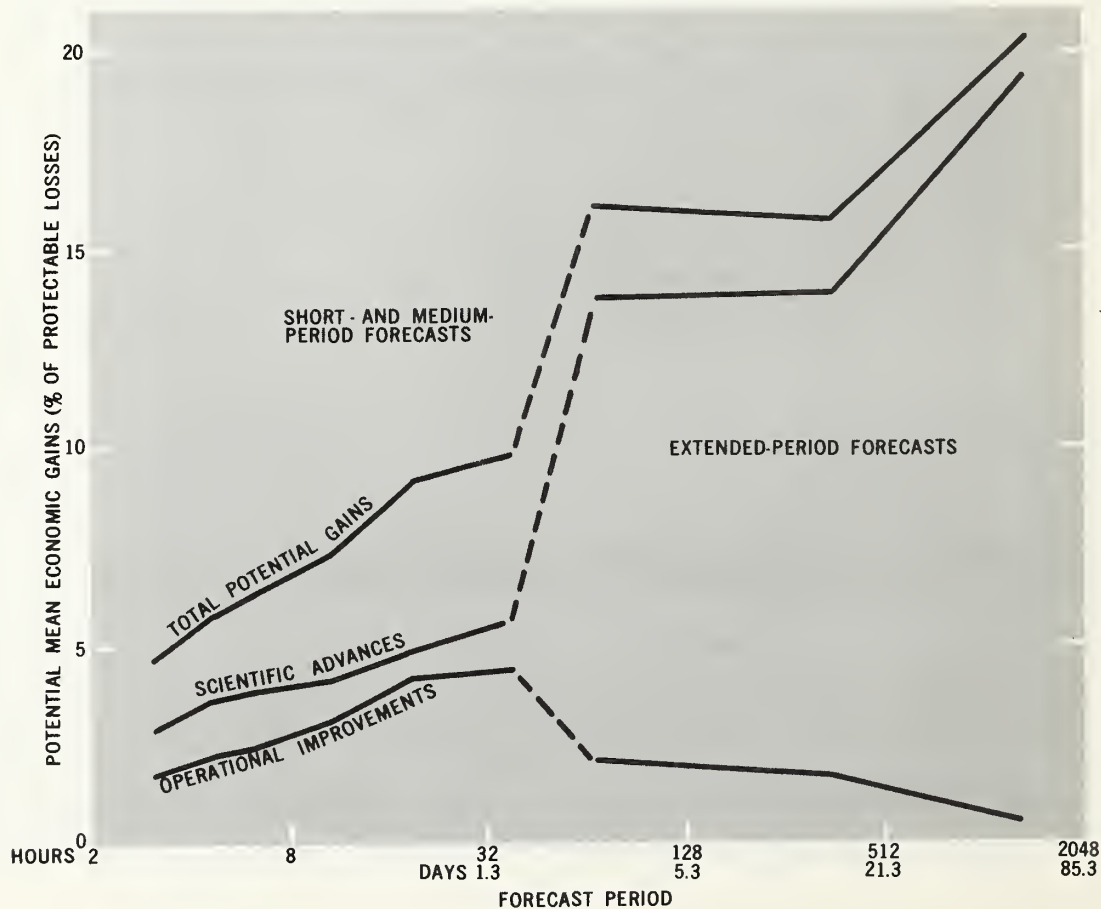


Figure 8. Average economic gains resulting from operational improvements, scientific advances, and total potential gains for various forecast periods. Short-period forecasts, up

to 7 hours, are for ceiling and visibility; medium- and extended-period forecasts, 12 hours or more, are for mean values of precipitation and temperature.

about \$15 billion. Of these losses, about one-third to one-half are the result of catastrophic weather against which protection is difficult or impossible. The other portion, about \$7 to \$10 billion, represent losses that improved weather information could alleviate. If one applies this rationale, it can be seen that the economic value of the present weather services exceeds the annual cost of their provision. These benefits, coupled with the savings of life and the maintenance of the Nation's security, suggest a very favorable cost-benefit relation. Figure 4 indicates the best estimate of improved forecast skill that can be expected during this decade. It is based upon technology that exists or is developing rapidly. The introduction of these new technologies into operational programs in an effort to achieve more reliable forecasts will be costly. Nevertheless, these costs should remain well below savings realized in the reduction of expenses associated with protectable weather losses.

BASIC METEOROLOGICAL SERVICE

DESCRIPTION

The Basic Meteorological Service provides the fundamental observations and forecasts used by the general public, departments and agencies of the Federal Government, and many segments of the economy. The Service meets many needs for observations, analyses and forecasts, and communications common to Specialized Meteorological Services, thereby avoiding duplication of facilities and effort.

The Department of Commerce's basic observing networks, meteorological satellite system, communications networks, and analysis and forecast centers are supplemented by the following contributions of other agencies:

- ☐ Surface observations from the Department of Defense, Federal Aviation Administration (FAA), and U.S. Coast Guard stations in the United States and overseas areas.
- ☐ Upper air (balloon and rocket) observations from Defense and National Aeronautics and Space Administration (NASA) stations in the United States and overseas areas.
- ☐ Surface observations from Coast Guard Ocean Station Vessels (OSV).
- ☐ Weather radar observations from Defense, NASA, and FAA radars.
- ☐ Aircraft in-flight reports from civil and U.S. military aircraft, worldwide.
- ☐ Synoptic and tropical storm reconnaissance by Defense aircraft.
- ☐ Climatic data from overseas areas.
- ☐ Typhoon warning services for the western North Pacific Ocean by the Defense Joint Typhoon Warning Center on Guam.
- ☐ High-speed data collection from overseas areas by Defense communication systems.
- ☐ Primary data collection and distribution in the United States by FAA teletypewriter systems.
- ☐ Marine forecast and warning distribution by Defense and Coast Guard radio facilities.

Four major weather-observing programs—surface, upper air, radar, and weather satellites—coupled with observations from other countries, provide the data base for fundamental analysis and forecasting activities of the Basic Meteorological Service.

Surface observations are made at fixed and mobile facilities on land and from ships at sea. In addition, a limited number of automatic weather stations and buoys are used for essential observations at unmanned or inaccessible locations on land and sea.

The Basic Upper Air Observation Network (balloon) is composed of Commerce facilities, with Defense and NASA participation at bases in the United States and overseas areas. Commerce funds the meteorological programs aboard the Coast Guard-operated OSVs, merchant and Government moving ships, and in the U.S. Trust Territory of the Pacific Islands. The Basic Upper Air Observation Network is supplemented in data-sparse areas by Defense weather reconnaissance flights, the Defense and NASA rocketsonde network, and in-flight aviation information reports.

Defense provides special typhoon and hurricane reconnaissance in the Pacific and conducts hurricane reconnaissance missions in the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico. In addition, extratropical storm flights are flown in the western Atlantic during the winter season. Defense aircraft fly year-round weather and special storm reconnaissance missions over a large portion of the ocean areas of the Northern Hemisphere and have a unique capability to fill partially the voids of upper air data in the troposphere and the lower stratosphere.

The Basic Weather Radar Network is composed of specified Commerce and Defense radars. NASA participates by providing information from those locations where its radars fulfill its own unique requirements. The FAA Air Traffic Control radars are also used in this Network to provide limited data in the mountainous areas of the Western United States.

Weather satellites are the fourth of the Basic Meteorological Service's observational programs. The satellite program is discussed in the Weather Satellites section of this Plan.

The principal analysis and forecast center of the Basic Meteorological Service is NOAA's National Meteorological Center (NMC), operated by Commerce at Suitland, Md. The Service provides both manually prepared and computer-produced analyses and prognoses for the Northern Hemisphere and for portions of the Southern Hemisphere.

NOAA's National Severe Storms Forecast Center (NSSFC) at Kansas City prepares forecasts and warnings of severe local storms, including tornadoes. NOAA's National Hurricane Center (NHC) at Miami prepares forecasts and warnings of hurricanes in the western Atlantic, Caribbean, and Gulf of Mexico. Smaller centers in San Francisco and Honolulu provide a similar service for the eastern and central North Pacific, respectively. Defense's Joint Typhoon Warning Center on Guam prepares typhoon warnings for the western North Pacific, west of longitude 180°. This Center operates the only national warning system in that area. Data and advisories are made available to all countries affected by these storms. NOAA's National Climatic Center at Asheville, N.C., partially supported by Defense, provides the central archival and retrieval facility for all meteorological data collected worldwide. A more detailed description of this facility is provided in a later subsection on Climatology.

Basic weather observations are collected and distributed principally by teletypewriter systems operated by FAA and NOAA. Weather charts prepared in basic analysis and forecast centers are distributed primarily to other centers and to local weather offices by means of the NOAA facsimile systems. Weather forecasts and warnings are prepared and then disseminated to the public through teletypewriter, telephone, and radio systems operated by NOAA and the Coast Guard and through mass-dissemination media. Specialized weather communications systems, established to meet international and Defense requirements, contribute to the Basic Meteorological Service as high-speed data links with overseas sources.

PLANS

Significant advancements are expected in satellite and computer technology and modeling techniques in the next few years. The objective is to integrate these advancements into the operational system for the purposes of extending the range and scope of forecasts and of improving operational

forecasting accuracy.

Significant improvement throughout the weather and river forecast and warning programs can be made by expediting development and implementation of more detailed and realistic operational prediction models. These programs will provide the basic meteorological analysis and forecast products from which effective national, regional, and local weather forecasts and warnings are prepared and disseminated to the user.

Effective utilization of new technologies demands a significant expansion of Federal activities directed toward more effective reduction of new environmental data from diverse sources and their assimilation into mathematical models, ultimately providing improved prediction. Advanced instruments to be flown on environmental satellites, beginning in calendar year 1972, will provide a variety of new and improved environmental observations. Atmospheric sounders scheduled to fly on ITOS and Nimbus will provide measurements from which vertical temperature profiles and geopotential heights can be derived for use in numerical weather forecasting. Higher resolution imagers (scanning radiometers sensing in both the visible and infrared spectra) will permit more detailed analyses of clouds, snow and ice cover, and sea-surface temperatures. Other satellite systems will collect environmental data from a variety of platforms in remote locations from which needed data are not now available. These data sources and the more advanced computers now planned can support impressively more complex and sophisticated mathematical models for the ocean-atmosphere system.

The composite of conventional and rich new data sources will not be assimilated in a satisfactory way and without a new level of effort. This must be directed toward the development of techniques and associated hardware for assimilating and interpreting data, defining initial states for prediction purposes, and developmental testing and evaluating of new techniques and models. The effort would also provide feedback to the development of future observational systems. The augmentation of present efforts would provide a most significant return, contributing literally to all of the Federal Government's meteorological prediction activities.

Present planning as reflected in the *Federal Plan for Meteorological Data from Satellites* calls for the first operational satellite atmospheric sounders to be available by 1972, with an improved sounder projected for about 1976. A prototype operational geostationary satellite, the Synchronous Meteorological Satellite (SMS), is programmed to

provide some data beginning in 1973 and is to be fully operational in a two-satellite geostationary configuration by 1974. The Geostationary Operational Environmental Satellite (GOES) system, when coupled with conventional weather observations, will provide the observational data needed to assure an adequate description of the atmosphere in great detail.

The *Computer Plan for Operational Forecasting and Atmospheric Modeling Research* states that a fourth-generation computer system will be operational by early 1973 and that a fifth-generation computer system is to become available for operational use by 1976. With the acquisition of fourth- and fifth-generation computers, it will be possible to use data secured by the satellite in the operational global prediction models, thus providing a capability to predict atmospheric and attendant weather changes with greater accuracy and for an extended period of time.

To achieve the desired objective, a systems approach is essential; three interdependent tasks have been identified and will be initiated in FY 1973. These tasks involve satellite data processing and reduction, data assimilation, and model test and evaluation.

- ☐ Satellite Data Processing and Reduction. The plan is to develop a satellite data processing and reduction technique which involves the preparation of all data into a convenient digitized format for further reduction to a consistent data set for insertion into numerical models. An essential part of the reduction process is continuing the evaluation and intercomparison of the derived meteorological quantities to identify inaccuracies and inconsistencies in the data provided to numerical models. This task involves comparing wind and temperature fields obtained from independent sources, identifying significant differences and their causes, instituting improvements, and developing techniques needed to provide a continuing quality control and evaluation of operational data.
- ☐ Data Assimilation. The plan is to redesign current analysis methods or to design new methods adapting the analysis-forecast system to the radically different time-space distribution of new satellite data sources.
- ☐ Model Test and Evaluation. The plan is to begin the development of new models consistent with increased computer power, with improved data coverage over the globe, and with the special characteristics of new observational systems—their accuracy, reliability,

and more or less random distribution in time. This task will include effective testing and evaluation of new numerical models before the operational implementation stage and during the model development stage.

Accomplishment of these tasks will permit marked improvement in the forecasts during the 1976–80 time frame as suggested in figure 4. The operations and research programs for FY 1973, described in the following paragraphs, are directed toward accomplishing these tasks.

OPERATIONAL PROGRAM FOR FY 1973

The operational program of the Basic Meteorological Service for FY 1973 reflects an increase of \$20,215,000 over FY 1972. The Department of Defense has reallocated its total resources among the Basic and Specialized Meteorological Services for FY 1973. It has increased its percentage of total resources as applying to the Basic Meteorological Service which accounts for the apparent increase in this area.

The Department of Commerce is planning a number of major improvements in its Basic Meteorological Service. Some of the more significant improvements by Commerce have been discussed previously in the section on the Weather Disaster Warning System. Other activities by the Department designed to improve services, include the following:

- ☐ Make greater utilization of automatic weather-observing stations and expand the automation of upper air observations.
- ☐ Improve the forecasting services to the public through an upgrade of a number of stations to Weather Service Forecast Office (WSFO) status.
- ☐ Begin a program to replace on a systematic basis overaged and outmoded equipment, to strengthen the maintenance program of both facilities and equipment, and to provide new facilities at a number of locations.
- ☐ Establish a program to assimilate the greatly increased amount of data expected from the developing satellite technology into the numerical prediction models.
- ☐ Make substantial progress toward completion of the coverage of the NOAA Weather Wire Service (NWWS) communications system.
- ☐ Improve the curriculum at its National Technical Training Center in Kansas City.

The FAA's Weather Message Switching Center at Kansas City became operational in FY 1972. While there are additional costs in FY 1973 to annualize the leased communications services, the total system provides for a greatly improved

weather communications system at a significant reduction in manpower and in dollar cost.

RESEARCH PROGRAM FOR FY 1973

The Department of Commerce in FY 1973 will continue to stress development of techniques for making objective predictions of all weather elements used in a public weather forecast. The work is being conducted on two levels, that is, (1) synoptic-scale weather, and (2) subsynoptic-scale weather. The effort on the synoptic-scale weather level is aimed at developing and implementing fully automated forecasts of amount of precipitation, probability of precipitation, amount of cloudiness, surface temperature, and surface wind from the output of the Primitive Equation model used at NMC for a network of 254 U.S. cities for periods of 24 to 60 hours in advance. Work will begin on the development of fully automated quantitative precipitation forecasts for 108 U.S. cities during FY 1973. The effort on the subsynoptic-scale weather level is based on developing a numerical model, the subsynoptic advection model (SAM), to predict precipitation on a space scale of 50 miles and on a time scale of 3 hours for projections up to 18 hours. Methods for producing forecasts of temperature and cloudiness on the subsynoptic scale will be developed in FY 1972. In addition, SAM, which formerly covered only the Eastern States, will be extended areally during FY 1972 to cover the Western States as well.

For the vital Hurricane Warning Service, the operational experimentation under Phase I of developing a data handling and display system for the NHC is expected to be completed. Phase I is a cycle of design, implementation, operation, and experimentation with a data handling and display system for NHC that will permit maximum effective operational utilization of data presently available to the Center and that data becoming available routinely by 1976.

In the area of severe local storms forecasting, efforts at NSSFC will be directed toward the development of automated techniques for predicting such phenomena as tornadoes, thunderstorms, hail, and damaging winds for periods up to 24 hours in advance. The trajectory model used in predicting probability, intensity, and motion of severe local storms was improved in FY 1972 by incorporating a diurnal temperature wave, by adding surface data in the initial analysis, and by using a better formulation of terrain effects. During FY 1972, severe storms prediction equations based on the perfect prognostic concept were derived, and experiments were conducted with severe storm forecasts

derived by the Model Output Statistics method. In major activities planned for FY 1973, digitized radar data will be applied to the short-range prediction of severe storms, and work will be accelerated on the development of a boundary-layer prediction model to serve as the primary numerical model for the future development of more accurate equations for both medium- and short-range prediction of severe storms.

Emphasis is also being placed on the application of automation techniques at NOAA National Weather Service (NWS) field stations that will enable field forecasters to perform their duties more effectively and efficiently. Work will focus on the installation of a model WSFO for use in experimentally evaluating and demonstrating automation techniques. In a related phase of this work already completed, computer-produced worded forecasts covering the standard today, tonight, and tomorrow forecast periods at several cities were developed. These forecasts can be displayed to the field forecaster for his review and possible modification. These forecasts will be expanded to encompass additional cities in FY 1973.

The National Hurricane Research Laboratory (NHRL) is developing theoretical-dynamical models of hurricanes, some of which simulate very well the life history of a hurricane isolated from its environment. Current efforts at NHRL are directed toward including the effect of the environment on the hurricane. When such a model has been developed, it should lead to greatly improved forecasts of hurricane tracks. In addition to the dynamical model development, work is continuing on the development of improved climatological-statistical models for predicting hurricane motion.

With reference to severe local storms observations and forecasting research program, emphasis continues on the collection and analysis of severe-storm events, including surface winds and gusts, heavy rainfall and hail, and analysis of radar data, to determine the motion predictability and water output characteristics of severe thunderstorms. The objectives of the program are as follows: First, to design, install, and test network configuration and surface stations that are capable of digitally recording and telemetering the wind speed and direction in a form suitable for immediate mesoscale observation of the low-level airflow in the environs of severe storms; second, to provide accurate data fields of wind velocity, temperature, pressure, humidity, and rainfall in a form suitable for use in post-mesoscale synoptic analysis of severe-storm periods; third, to operate a tall meteorological tower and radio station for obtaining meteorological pro-

files of wind, temperature, and humidity in the lower and middle troposphere during severe-storm periods; fourth, to analyze severe-storm events, including hail falls, heavy rainfall, tornadoes, and strong wind gusts, and to relate these events to quantitative weather radar data; and fifth, to develop techniques for the analysis, display, and tracking of severe-storm events that would lead to the improvement of severe thunderstorm warnings.

Major efforts in NOAA are devoted to developing families of modular automatic weather-observing stations for use as follows: (1) at locations where communications, power, and maintenance are available; and (2) at remote, unmanned locations where maintenance is difficult and communications and power are generally unavailable. For use (1), a prototype automatic weather station, the Automatic Meteorological Observing Station (AMOS III-70), that is compatible with Service-A teletypewriter communications was developed before FY 1972, and add-on modules for measuring an index of visibility, precipitation occurrence, and peak winds were completed in FY 1972. During FY 1972, a coastal AMOS for use at Coast Guard sites was successfully developed, installed at three sites, and demonstrated. In FY 1973, a cloud index module will be developed, tested, and evaluated. For use (2), a design concept for a Remote AMOS (RAMOS) has been prepared and three RAMOS I prototypes have been developed. In FY 1973, the test and evaluation of the RAMOS I (the basic RAMOS) and the design of add-on components to it will be completed. Development work will be conducted on sensors for the RAMOS "x," a follow-on to the RAMOS I for use at larger observing stations.

Work on real-time test bed operations of the field Digitized/Radar Experiment (D/RADEX) continues in Commerce, but most radar work in FY 1973 will focus on applied technical experiments to assess potential hydrological and meteorological applications of digital radar data. Plans are expected to be completed during the Fiscal Year for the development of the next-generation network radar for the NWS. The writing of specifications for a local use/gap filler radar is planned, and an investigation into the practicality of instant-radar reply will be made.

Test and evaluation of the Next-Generation Upper Air System (NEXAIR), which is based on the use of Loran-C and Omega navigation aids, is scheduled for completion by NOAA in FY 1973. This new upper air sounding system should satisfy the macroscale, mesoscale, and microscale requirements for wind, temperature, pressure, and humid-

ity data during the 1970's. The preproduction model procurement specifications for NEXAIR will also be generated in this Fiscal Year, and a low-density sonde will be developed to ensure a collision-safe sounding system.

Further development of four all-weather techniques to measure remotely the profiles of temperature, wind, and humidity to 20,000 feet or higher will be emphasized. The first technique, a prototype acoustic system for measuring humidity, will be constructed in FY 1973 and measurements from this new system will be initiated. Previously, in FY 1972, a bistatic acoustic system was constructed, and temperature and wind measurements with the new system began. Work on the second technique, microwave radiometry, aims to improve the accuracy, resolution, and height range of the currently available techniques for sensing temperatures; this work will continue. A third technique, the Electromagnetic Acoustic (EMAC) method, involves the construction and operation of a low-frequency radar to compare EMAC-derived temperatures with radiosonde temperatures. A new effort, comprising the fourth technique, will investigate active and passive cross-correlation techniques for remote sensing.

Development of a preliminary design concept for the communications system needed to meet the requirements of the NWS during the late 1970's and early 1980's will be completed in FY 1973. Work for this design phase includes: consideration of the impact of GOES-type data collection; provisions for digitized radar data; development of other automation efforts in data acquisition, processing, display, and dissemination; acquisition of mobile units for low-level upper air soundings and fire-weather observations; and consolidation and standardization of NWS communications.

With reference to climatology, Commerce is initiating a project on the detection of climatic variation and its relation to both natural and manmade causes. Preliminary postulates of likely effects of changing particulate matter and carbon dioxide, for example, in the atmosphere have been offered; new data will provide verification or correction of these influences on cooling and heating of the atmosphere. A study is underway to describe the climatic change in the United States and on a worldwide basis. It will evaluate the statistical character of climatic change and will establish the quantitative role of general circulation changes in causing climatic change. The physical causes of climatic change are also being examined. A study of satellite data should provide clues to the extent that pollution affects climate and to the possible use that pol-

lution can play as an independent measure of cloud cover. Determination is being made of the extent to which climatic prediction may be feasible on a physical basis as distinct from a purely empirical (statistical) basis. The objective is to prepare, if practicable, specific climatic forecasts for the United States, together with estimates of their reliability. Observational techniques will be examined so that improved methods of data collection that involve climatological analysis can be achieved.

In applied climatology, efforts are directed toward: (1) defining critical relations and thresholds through which environmental conditions affect structural design, operating enterprises, and economic and social activities; (2) estimating probable occurrence of such critical conditions as a basis for planning, design, and insurance measures; (3) devising ways to avoid or to alleviate these conditions through analysis and understanding of climatological records; and (4) advising archivists and data processors of the data needs of practical users in terms of length of record, site documentation, quality, variability, redundancy, and storage format.

Within the Department of Defense, research in Basic Meteorological Service involves increasing emphasis in the areas of numerical analysis, modeling, and prediction. Substantial efforts are being made to improve global analysis and forecast models; tropical forecasting; high-altitude (stratosphere and near-earth space) observing; analysis and forecasting; and improved capabilities for local-area computerized forecasts, including an auto-

mated "weather watch" for ships at sea. Additional efforts are continuing to improve observing systems; balloonsondes, rocketsondes, and dropsondes; automatic weather stations; and radar and other aircraft reconnaissance equipment. A comprehensive program for the automated collection, dissemination, and display of meteorological information is under development and will continue for a number of years into the future.

Results of research efforts by NASA are of significant importance to the Basic Meteorological Service. The improvement program for satellite systems provides the majority of research funds to improve this Service area. A substantial portion of the effort is for the continued development of SMS, the prototype of GOES, and of the Nimbus E and F spacecraft. The Nimbus E and F missions will result in substantial new research and development, providing a definitive basis for future remote sounders. Techniques planned for testing on these missions are expected to sound through clouds, to obtain better vertical resolution, to extend soundings to higher altitudes, and to relate microwave and infrared soundings. Significant improvements should result from research and development in support of the Global Atmospheric Research Program for finding the best techniques to measure winds in the tropical regions and to provide reference levels in remote regions of the globe. The weather satellite programs of NASA and other agencies are treated in more detail in the Weather Satellites section of this Plan.

BASIC METEOROLOGICAL SERVICE, BY AGENCY

	Operations		Supporting research		Total	
	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73
Commerce.....	115,057	129,648	3,558	3,508	118,615	133,156
Defense:.....	(32,114)	(37,111)	(4,300)	(3,550)	(36,414)	(40,661)
Navy.....	8,361	8,322			8,361	8,322
Air Force.....	23,753	28,789	4,300	3,550	28,053	32,339
NASA.....			43,120	61,433	43,120	61,433
Transportation:.....	(19,357)	(19,984)			(19,357)	(19,984)
Coast Guard.....	10,611	11,505			10,611	11,505
FAA.....	8,746	8,479			8,746	8,479
Total.....	166,528	186,743	50,978	68,491	217,506	255,234

AVIATION METEOROLOGICAL SERVICE

DESCRIPTION

The Aviation Meteorological Service furnishes specialized weather information to pilots, dispatchers, air traffic controllers, and fixed base operators to promote safety and efficiency in civil and military aviation activities. Responsibility for the Service is shared among three Federal Departments—Commerce, Transportation, and Defense. The Department of Commerce serves domestic and international civil aviation. The Department of Transportation makes recommendations to Commerce on civil aviation meteorological services, provides specialized equipment and surface observations at certain airfields, disseminates weather information to users, and distributes weather data over civil teletypewriter systems. The Department of Defense serves the global needs of military aviation and makes meteorological information from its weather reconnaissance and other facilities available to civil aviation.

Specialized surface observations, primarily in support of aviation, are made at approximately 522 civil and military locations in the United States. On the civil side, Commerce provides these observations at eight locations and the FAA at 346 locations. These figures do not include cooperative observations made by private operators at many smaller airports, nor the many observations taken for the Basic Meteorological Service. Defense makes surface observations primarily for aviation at approximately 178 locations. At many locations, the surface observation program is a coordinated effort between Commerce and FAA, or one of the Defense agencies.

Analyses and forecasts for aviation purposes are prepared by weather centrals, weather forecast offices, and weather service offices. Commerce operates 40 Weather Service Forecast Offices (WSFO) in the United States in support of domestic aviation; Defense operates four primary centers, 17 area centers, and four specialized centers in the United States in support of military requirements. These centralized facilities provide areawide guidance and forecasts for use by local weather offices and by briefing facilities at the terminals. Detailed local forecasts are prepared for over 400 terminals on a routine basis by 42 NOAA WSFOs (this includes San Juan and Wake Island); analyses and forecasts for international civil aviation are provided by six NOAA WSFOs in accordance with procedures recommended by the International Civil Aviation Organization for the North Pacific, Central American, Caribbean, North Atlantic, and West European areas. Ten Defense weather service

offices also provide support to international civil aviation in the interest of efficiency and economy. Cooperative Federal programs are conducted at the National Meteorological Center (NMC) of NOAA and at the Fleet Weather Central at Pearl Harbor, Hawaii. Private industries obtain meteorological products from the NMC over computer-to-computer links at no cost to the Federal Government for computerized flight planning. Specialized Defense units prepare computer flight plans—an average of more than 1,200 routes daily—in support of worldwide tactical and strategic military aircraft movements.

Weather observations and other information in support of domestic civil aviation are collected and distributed over the FAA teletypewriter Service A and over the Basic Meteorological Service teletypewriter systems. Defense agencies use the Continental United States Meteorological (COMET) teletypewriter system to meet the needs of military aviation in the United States. International exchanges of aviation meteorological data and information are carried on the Aeronautical Fixed Telecommunications Network teletypewriter systems operated by FAA and on the high-speed systems of the Basic Meteorological Service. The Automated Weather Network (AWN) of Defense provides for high-speed collection of data from overseas areas to meet Defense aviation requirements; data from this system are provided to the NMC. The NMC places certain North American data for distribution to military users on the AWN.

Specialized weather charts for aviation purposes are distributed from the analysis and forecast centers to local weather offices and briefing facilities—Weather Service Offices (WSO), WSFOs, and Flight Service Stations (FSS)—over the National and Aviation Facsimile Networks of Commerce. The Strategic Facsimile Circuit of Defense meets that Department's additional specialized requirements.

Voice communications systems are used widely in the Aviation Meteorological Service. The air-ground radio systems of FAA are used to provide weather information to and obtain data from pilots. Weather observations, forecasts, and advisories are carried as scheduled broadcasts on over 800 air navigation aids and as continuous transcribed weather broadcasts for 48 locations. The Pilots Automatic Telephone Weather Answering Service (PATWAS) provides forecasts covering a 250-mile radius at over 50 locations, plus 10 additional locations which cover the local areas only. The FAA has a telephone network linking airports without a local weather briefing outlet to a nearby FSS.

Pilots use this network to file flight plans and to obtain preflight weather briefings. Airborne pilot can receive a weather briefing by radio contact with a FSS. The Department of Defense operates a network of air-ground radio stations for direct pilot-to-forecaster contact to provide observations, forecasts, and warnings on request to airborne military pilots and to obtain in-flight weather reports from military aircraft.

Aviation weather briefings are available to pilots through approximately 600 manned and 150 unmanned facilities. These services are provided by the Department of Commerce and by FAA. At the air terminals where a NOAA-WSO and a FAA-FSS are collocated, FSS personnel handle the routine weather briefings. Users requiring more technical meteorological assistance are referred to the NOAA WSO. The FAA provides over 13 million pilot weather briefings annually and NOAA about 2 million. Defense prepares detailed flight weather briefings at some 220 terminals and provides approximately 2 million flight briefings annually.

OPERATIONAL PROGRAM FOR FY 1973

The operational program of the Aviation Meteorological Service for FY 1973 reflects a decrease of \$8,309,000 over FY 1972. This net change is primarily the result of the Department of Defense reallocating its resources among the Meteorological Services. The Department of Defense is improving runway instrumentation at a number of U.S. Air Force bases in FY 1972 and at Naval and Marine Corps stations in FY 1973. An Air Force program to expand its radar remote transmitters and receivers in FY 1972 is being held in abeyance pending further test and evaluation. Both the Navy and Air Force are reducing the aircraft flying hours devoted to weather reconnaissance, but at the same time, each is expending resources for aircraft modification to provide increased reconnaissance capability. The FAA is continuing its program of improving services to aviation with the addition of rotating-beam ceilometers and Runway Visual Range units at a number of Category I and II airports; the objective is to automate observing equipment and to lower landing minimums. With the expanding aviation activity, the FAA is planning and preparing for an increase of 2.1 million pilot weather briefings, from 13.2 to 15.3 million, during the Fiscal Year.

RESEARCH PROGRAM FOR FY 1973

The Department of Commerce is continuing work aimed at an identification of observing techniques that will enable complete automation of syn-

optic and aviation observations. Sensors will be procured for field validation of visibility, cloud, and freezing-rain-measuring techniques to confirm the theoretical work accomplished with mathematical models that involves the automation of aviation surface weather observations. In addition, a technique will be developed for reconstructing, at a weather office, cloud and visibility measurements which are taken automatically by sensors located at various sites that fill gaps in the existing surface-observing network.

Commerce is also stressing the demonstration, test, and evaluation of alternative methods for the dissemination of aviation weather products to general aviation pilots. The goal is to find an optimum configuration of weather dissemination techniques which provides the weather data necessary for safe and efficient utilization of the national air space, with convenience to the pilot, and remains consistent with the overall national weather system.

The research effort by the Department of Defense in support of Aviation Meteorological Service has undergone some redirection since FY 1972. A new effort has been mounted to make needed improvements to short-range terminal forecasting techniques. Work is also underway to increase the reliability and precision of computer-generated flight plans. Instruments which are designed to support land- and sea-based aviation operations continue to receive attention, and a modest effort to design a reliable CAT detection device is being funded again in FY 1973.

The aviation weather research program of the Department of Transportation is designed to provide the technical and operational developments needed that will improve the performance and use of existing components of weather acquisition, transfer, processing, and display equipment. The objective is to modify these specific components for integration into the modernized configuration of the National Airspace System. In this program, the FAA will continue to develop improved techniques for hazardous weather and turbulence detection. By using Doppler radar and other detection devices, the FAA will evaluate techniques and equipment for detecting and predicting CAT. It will continue to develop automated methods for improving the accuracy, timeliness, and reliability of aviation terminal forecasts.

In addition, the FAA will investigate methods of improving pilot briefings at FSSs and the feasibility of using automatic data processing equipment for use in briefing pilots; will continue investigations to improve CAT forecasts; will conduct research on alleviating the effects of aircraft wake turbulence;

AVIATION METEOROLOGICAL SERVICE, BY AGENCY

	Operations		Supporting research		Total	
	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73
Commerce.....	14,568	15,210	285	275	14,853	15,485
Defense:.....	(106,944)	(97,146)	(475)	(475)	(107,419)	(97,621)
Navy.....	10,452	10,778			10,452	10,778
Air Force.....	96,492	86,368	475	475	96,967	86,843
Transportation:.....	(34,925)	(35,773)	(5,853)	(5,615)	(40,778)	(41,388)
Coast Guard.....	1,215	1,314			1,215	1,315
FAA.....	33,710	34,458	5,853	5,615	39,563	40,073
Total.....	156,437	148,128	6,613	6,365	163,050	154,493

and will investigate meteorological environment in built-up areas as it applies to the operation of vertical and short takeoff and landing (V/STOL) aircraft.

In the area of CAT, NASA is investigating atmospheric turbulence to establish the relation between turbulence and synoptic meteorological conditions. The procedure involves concurrent use of detailed Jimsphere (a specially designed balloon) wind profile data and high-resolution temperature data obtained from a temperature sensor designed by NASA and flown on the Jimsphere wind sensor. Other CAT studies have resulted in the development of a wind velocity sensor that uses the coherent detection of Doppler-shifted radiation scattered from atmospheric particulates. The developed instrumentation consists of a continuous-wave carbon-dioxide laser source coupled to the atmosphere by means of a telescope which serves as the backscatter collector. This type of instrumentation will be used as an in-flight system to detect CAT and to provide detection of various locally generated phenomena such as aircraft wingtip vortices.

MARINE METEOROLOGICAL SERVICE

DESCRIPTION

The Departments of Commerce, Transportation, and Defense share statutory responsibility for the Marine Meteorological Service. That Service is designed to promote the efficiency of marine civil and naval operations and to ensure the safety of life and property at sea and on coastal and inland waters. Many segments of the economy—including shipping, commercial fishing, offshore drilling and mining, and recreational boating—as well as the De-

partments of Defense, Transportation (U.S. Coast Guard), and the Interior require detailed forecasts of tides, winds, sea state, surf conditions, and storms. The Department of Commerce is responsible for collecting observations, for issuing forecasts and warnings, and for disseminating marine meteorological information to benefit the marine industry and navigation. The Coast Guard is responsible for assisting Commerce by furnishing observations and by disseminating warnings and weather information for the high seas and waters over which the United States has jurisdiction. The Department of Defense is responsible for providing marine meteorological information to its forces.

While at sea, all major commissioned vessels of the U.S. Navy make weather reports that supplement observations largely supplied by the Basic Meteorological Service. Approximately 38 naval vessels have sophisticated equipment for more detailed surface observations, with about 36 of these vessels equipped to make upper air observations. A limited number of buoy-mounted automatic weather stations, now in the research and development stage, are deployed and report regularly. Naval observations are made available to other Federal agencies through routine data collection and exchange. In addition, all large Coast Guard cutters make weather reports while at sea; more than 33 Coast Guard vessels are equipped with balloon inflation shelters for use in making upper air observations when required.

NOAA supplements the analysis and forecasting functions of the Basic Meteorological Service with specialized marine support operations at a number of its Weather Service Forecast Offices (WSFO). A Marine Forecast Unit has been established at

WSFO Anchorage, Alaska, to meet service requirements in Alaskan waters, including the Bering, Chukchi, and Beaufort Seas. Particular attention is given to sea ice and its effect on shipping and drilling operations. Another Marine Forecast Unit has been established recently at WSFO Washington to serve offshore and high seas areas of the North Atlantic Ocean. Other WSFOs at San Francisco and Honolulu have major marine service responsibilities. These include the meeting of minimum analyses and forecasting requirements in the high seas areas of the North Pacific Ocean where the United States has responsibility for shipping forecasts and warnings under the Safety of Life at Sea and World Meteorological Organization Conventions. In the extreme western North Pacific, Defense provides those services. Marine forecasts and warnings are issued by 17 WSFOs for coastal and offshore waters and by three WSFOs for the Great Lakes. Twenty-one WSFOs provide services to recreational boaters for lakes and waterways within their area of responsibility as part of the public forecast program.

A total of 13 Fleet Weather Centrals and Facilities supplement the broad-scale products from the Navy's Fleet Numerical Weather Central (FNWC) and NOAA's National Meteorological Center (NMC) by preparing detailed analyses, forecasts, and warnings for their assigned areas of responsibility. In addition, the FNWC and two of the Fleet Weather Centrals furnish optimum-track ship-routing services to naval vessels and to commercial ships operating under Department of Defense contract.

Naval units supplement the Basic Meteorological Service data collection, distribution, and dissemination systems by transmitting weather information along with other traffic on Defense communications systems. In addition, the Naval Environmental Data Network provides for computer-to-computer distribution of products from the FNWC to other Fleet Weather Centrals and Facilities in the United States and overseas areas.

Automatic telephone-answering systems operated by Commerce provide marine users with the latest forecasts and warnings at eight locations; 61 VHF/FM radio broadcast stations now in operation or under installation carry similar information. More than 2,000 commercial radio and television stations broadcast marine information several times daily as a public service. In addition, seven NOAA-operated radio stations (in Alaska), 46 Coast Guard stations, and 43 commercial radio stations transmit forecasts and warnings for coastal and offshore areas. Weather information for shipping on the high seas in the western North Atlantic

and in the eastern and central North Pacific is broadcast by Coast Guard, Defense, and commercial radio stations. In 1971, a special new service for high-seas shipping was inaugurated by NOAA in cooperation with the National Bureau of Standards, using the time-signal broadcast facilities of WWV (Colorado) and WWVH (Hawaii). This new service consists of brief (42-second) broadcasts made each hour, giving information on major storms in the North Atlantic and in the North Pacific. Facsimile service is available to specially equipped ships from Coast Guard and Defense broadcasts. All Defense naval broadcasts—radio-teletypewriter, voice, and facsimile—are primarily for support to naval forces and are subject to change in schedule and content on minimum notice.

Personal marine briefing services are available at all WSFOs having marine service programs; however, most users rely on the various communications systems or on the Coastal Warning System for their information. The latter System is a cooperative network of about 500 visual (flag and light) signals at prominent locations along the coasts, Great Lakes, and inland waterways to advise marine interests when warnings are in effect. The Coast Guard and NOAA operate about one-half of these displays; the remainder are operated by non-Federal interests.

More than 60 Defense weather offices at shore stations and aboard larger ships provide Marine Meteorological Service in support of naval operations.

OPERATIONAL PROGRAM FOR FY 1973

The operational program of the Marine Meteorological Service for FY 1973 reflects an increase of \$741,000 over FY 1972. The Department of Defense program provides for the replacement of miscellaneous items for automatic and buoy stations, for an upgrade of a number of shipboard automatic picture transmission systems, and for the establishment of 13 Geostationary Operational Environmental Satellite/facsimile-display stations. The Department of Commerce is expanding its program primarily through increased forecasting services. A new Marine Forecast Unit is being established at San Francisco, and others augmented. Additional graphical guidance products are to be provided, both for analyses and forecasts by the NMC.

RESEARCH PROGRAM FOR FY 1973

The Department of Commerce is continuing to emphasize development of automated techniques for the production of marine environmental observations and forecasts for oceanic areas, coastal

MARINE METEOROLOGICAL SERVICE, BY AGENCY

	Operations		Supporting research		Total	
	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73
Commerce.....	1,331	1,640	100	110	1,431	1,750
Defense:.....	(8,710)	(8,982)	(543)	(561)	(9,253)	(9,543)
Navy.....	8,710	8,982	543	561	9,253	9,543
Transportation:.....	(354)	(514)			(354)	(514)
Coast Guard.....	354	514			354	514
Total.....	10,395	11,136	643	671	11,038	11,807

areas, and the Great Lakes. Work will begin on developing a hurricane storm-surge forecasting model for use with those storms that move along the shore rather than inland. Experimental research buoys will be deployed in the Gulf of Mexico. The funds associated with the buoy development are reported in the *Federal Plan for Marine Environmental Prediction for FY 1973*. A technique for forecasting breakers by applying simple refraction and shoaling processes will be completed and made operational in FY 1973. Work will also begin in FY 1973 on developing techniques for forecasting sea-surface temperature, for forecasting the vertical temperature structure over water, and for predicting ice conditions.

The Department of Defense is continuing its effort toward the development of analysis and prediction models and of techniques that will provide a global, automated prediction system. The system will collect, process, disseminate, and display environmental information for use in problems unique to military operations on a near real-time basis. The overall objective is the development of a total system which will, through automatic data-processing techniques, process and analyze raw data from land-based, shipboard, airborne, buoy, and satellite meteorological- and oceanographic-measuring systems. Command estimates of the prospective success of environmentally sensitive military operations may then be made by using accurate environmental predictions and interpretations which are derived from advanced data processing and analysis techniques that use air- and sea-coupled mathematical models.

SPACE OPERATIONS METEOROLOGICAL SERVICE

DESCRIPTION

The Space Operations Meteorological Service provides the specialized weather information re-

quired to plan and conduct the Nation's space and missile programs.

Launch sites, missile test ranges, and sometimes recovery areas are instrumented by the user agency to furnish weather information from the earth's surface to an altitude of about 60 kilometers. This information is necessary to determine the conditions that missiles and space vehicles will encounter as they are launched or reenter the atmosphere.

Weather observations from local, national, and international networks are used along with weather radar, satellite, and aircraft reconnaissance data as a basis for forecasts and warnings of weather which might affect launch or landing-and-recovery operations.

A number of the NASA programs are supported by meteorologists from the Department of Commerce National Weather Service (NWS). There are NWS teams at NASA facilities at the Wallops Station, Wallops Island, Va.; the Mississippi Test Facility, Bay Saint Louis, Miss.; the J.F. Kennedy Space Center, Cape Kennedy, Fla.; and the Manned Spacecraft Center, Houston, Tex. The staffs at the latter two NASA Centers are aided by dedicated meteorologists working at the NWS National Meteorological Center, the NOAA National Environmental Satellite Service, and at NWS offices in Miami and Honolulu. The effort ranges from design support studies through participation in flight missions, with exacting weather requirements for launch and recovery.

The Department of Defense provides the Space Operations Meteorological Service for the Eastern Test Range, the Space and Missile Test Center, and the Pacific Missile Range. Networks of surface, radiosonde, and weather radar stations are located on islands and on ships stationed within the Ranges. Planning studies and operational weather forecasting are performed by specialized staffs at Range Weather Stations. Observations are provided by Defense personnel through contracts with

SPACE OPERATIONS METEOROLOGICAL SERVICE, BY AGENCY

	Operations		Supporting research		Total	
	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73
Defense:.....	(5,150)	(7,917)	(164)	(164)	(5,314)	(8,081)
Army.....			164	164	164	164
Navy.....	697	719			697	719
Air Force.....	4,453	7,198			4,453	7,198
NASA.....	1,488	1,666	2,285	2,500	3,773	4,166
Total.....	6,638	9,583	2,449	2,664	9,087	12,247

private industry or through funded agreements with Commerce. Defense also provides for participation in the Meteorological Rocket Network formed to gather atmospheric data from 30 to 110 kilometers above the earth as required by Defense, NASA, the Defense Nuclear Agency, and NOAA for their respective missile, space exploration, atmospheric research, and nuclear effects research projects. Meteorological support to the White Sands, N. Mex., and Kwajalein Missile Ranges and to other Defense-operated research and testing facilities is provided from Defense-supported research funds.

Particularly in the service to manned space flights, there must be weather surveillance and forecasting for large areas of the world to provide for the planned and the many possible emergency landing areas. Meteorological satellite products are extensively used to provide this Space Operations Meteorological Service, especially for the remote ocean areas of both hemispheres.

OPERATIONAL PROGRAM FOR FY 1973

The operational program of the Space Operations Meteorological Service reflects an increase of \$2,945,000 over FY 1972. The significant change in the level of funding budgeted for the Space Operations Meteorological Service for FY 1973 is the result of the Department of Defense reallocating its resources among the Meteorological Services. There are no actual significant changes in this Service; however, continuing in-house efforts are being made to improve the existing Service.

RESEARCH PROGRAM FOR FY 1973

Defense has a continuing program for the development of improved meteorological instrumentation to meet the specialized needs of both the Eastern Test Range and the Space and Missile Test Center. Specialized instrumentation and data are

used to assist in scheduling launch operations, in evaluating missile and payload flight performance, in making reentry calculations, and in ensuring range safety.

As part of its supporting research program, NASA is improving rockets and rocketborne instruments and is investigating upper atmospheric phenomena through use of rocket data. The NWS teams that are supporting the NASA manned space programs operationally also conduct a variety of studies oriented toward mission planning and toward development of forecasting techniques for future flights.

AGRICULTURAL METEOROLOGICAL SERVICE

DESCRIPTION

The Agricultural Meteorological Service, which includes the Agricultural, Fire-Weather, and Fruit-Frost Weather Services, provides specialized observations, forecasts, warning, and reports to the agricultural community and to the forestry-range management interests. The Department of Commerce is responsible for planning and conducting this Service. The Departments of Agriculture and the Interior assist in planning and participate in cooperative programs for observations, communications, and distribution of information.

Two programs are operated by Commerce to provide service to agriculture and forestry-range management user groups. The *Federal Plan for a National Agricultural Weather Service* describes one program. The other is a program to support presuppression, suppression, fire use, and other forestry-range management activities of Federal, State, and private interests. Four and one-half phases of a nine-phase plan for a nationwide service have been implemented according to the *Federal Plan for a National Fire-Weather Service*.

Specialized observation networks are maintained in agricultural and forestry areas remote from the normal observing sites in or near urban areas. In most cases, observations are made on a cooperative basis between NOAA and other Federal agencies, States, or private interests. Thousands of private citizens serving without pay provide daily measurements of air and soil temperatures, rainfall, and evaporation in crop areas. Observing programs are also conducted in cooperation with Federal and State agencies at Agricultural Experiment Stations, colleges, and universities to obtain detailed micro-meteorological data for use in studies of agriculture-meteorology relations. Approximately 1,100 fire-weather observing stations operate on a seasonal basis in forested areas; they report daily, with costs borne by governmental or private interests. Commerce also uses mobile equipment to provide on-the-spot support to fire-fighting operations in Western States.

The NOAA Weather Wire Service, operated by Commerce, disseminates forecasts, warnings, and advisories to users and to the mass media in each of the 12 service areas that are now provided the national Agricultural Weather Service. Communications systems, including two-way radios, of Federal and State fire-control agencies are also used to collect observations and to distribute forecasts and warnings supplementing seasonal fire-weather teleprinter circuits of the Department.

Forecasts for agricultural users—ranging from a short-period forecast which affects planting, harvesting, crop dusting, and spraying to a 30-day outlook for general agricultural planning—are prepared at Commerce Weather Service Forecast Offices located in each of the 12 service areas. Interpretive and consulting services are provided by 19 Weather Service Offices (Agriculture) located at Federal or State experimental stations. A new service for wool growers and livestock producers in Wyoming, North Dakota, and South Dakota has been inaugurated. From mid-October to mid-May, this service provides forecasts and warnings which are continuously available by recorded telephone.

Forecasts for fire-weather users—ranging from 36- to 48-hour general forecasts of weather patterns and meteorological elements, such as winds, temperature, rainfall, humidity, thunderstorms, and fuel moisture for large areas, to short-period forecasts for a specific forest fire or to warnings of unusually high fire danger in a forest—are prepared at Weather Service Offices (Fire-Weather) by specially trained personnel. The Forest Service of Agriculture contributes to the Fire-Weather Service by supplying fire-weather observations for some 1,100

locations scattered through the national and State forests. Broad-scale guidance is furnished by the Analysis and Forecast Division of the NOAA National Meteorological Center. Although the FAA does not specifically budget funds for the national Fire-Weather Service, the agency plays a significant role by obtaining pilot reports of fires and by controlling aircraft involved in fire-fighting work. These fire-fighting aircraft require precise observations and forecasts for their hazardous missions.

Forty-three Primary Fire-Weather Offices provide detailed forecasts to local users within their assigned districts and eight Supplementary Fire-Weather Offices provide similar support in addition to their normal public weather service functions. Twenty truck-mounted mobile units, with two-way radio and radio facsimile, deploy at major forest fires to provide immediate support to fire-fighting operations.

OPERATIONAL PROGRAM FOR FY 1973

The operational program of the Agricultural Meteorological Service reflects an increase in FY 1973 of \$423,000 over FY 1972. This increase is the result of the Department of Commerce effort to fulfill its responsibilities as indicated in the *Federal Plan for a National Agricultural Weather Service*. In this regard, Commerce plans to implement the Agricultural Weather Service program in Arizona, Montana, Nebraska, New York, North Carolina, Ohio, and Wyoming and to augment the Service in other States.

RESEARCH PROGRAM FOR FY 1973

The Department of Agriculture is funding the major portion of the supporting research for the Agricultural Meteorological Service. Studies are being conducted to determine the meteorological factors associated with various types of plant diseases that will provide the criteria for forecasting those diseases with epidemic potential. Other studies include the relation between crop yield and windbreaks that influence the movements of air, soil, water, and snow. The relation between climate and that of cold hardiness, fruit quality, productivity, and drought resistance of citrus are being determined. The Department is supporting the analysis of weather data from surface and satellite observations to evaluate the environmental effects and the fundamental impact of atmospheric variables on plant growth and yield. Simulation models are being constructed to maximize the climatic resources in agricultural decision-making; those atmospheric conditions conducive to air pollution are also being investigated.

AGRICULTURAL METEOROLOGICAL SERVICE, BY AGENCY

	Operations		Supporting research		Total	
	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73
Agriculture.....			820	879	820	879
Commerce.....	1,759	2,182	170	155	1,929	2,337
Total.....	1,759	2,182	990	1,034	2,749	3,216

GENERAL MILITARY METEOROLOGICAL SERVICE

DESCRIPTION

In fulfilling its mission to preserve the peace and the Nation's security, the Department of Defense requires worldwide meteorological support. The General Military Meteorological Service provides general military users with support not available from the Basic Meteorological Service or from other Specialized Meteorological Services. Support for specific users, such as aviation, marine, and space operations, is included in the subsections on the relevant Specialized Meteorological Services.

Requirements of military user groups include: meteorological information tailored to the particular weapons system being developed or employed; unique forecasts and analyses used by command and control systems; specialized information such as ballistic data required by field armies; specialized forecast, impact prediction, meteorological advisory services, and post-test analysis assistance to research, development, test, and evaluation sites; and general meteorological support needed in the training and deployment of military forces and in contingency operations.

Various elements of Defense require special meteorological services. To provide these services, the Department maintains analysis and forecasting facilities in the United States and overseas areas. Defense operates the Air Force Global Weather Central (AFGWC) at Offutt Air Force Base, Nebr., the Fleet Numerical Weather Central (FNWC) at Monterey, Calif., and forecast centers in Europe, the Pacific, and the Far East. Specialized centers—such as the U.S. Air Force Environmental Technical Applications Center (ETAC) at Washington—also fulfill unique military meteorological requirements. Similarly, Defense observation facilities are operated to obtain data in direct support of military operations. Military communications net-

works are maintained to collect and exchange observations and to disseminate forecasts. Whenever possible, these observations are made available to other Federal agencies to help meet overall requirements.

Also, the Defense aerial reconnaissance force plays a paramount role in specific Defense operations. It provides refueling and en route weather observations for tactical deployments and contingency exercises, wind information for mass air-drop exercises, and weather observations for missile recovery areas.

In support of tactical operations, the Department has developed a series of air-transportable van complexes capable of providing complete meteorological support to deployed forces.

OPERATIONAL PROGRAM FOR FY 1973

The operational program of the General Military Meteorological Service for FY 1973 reflects a decrease of \$4,444,000 from FY 1972. The Department of Defense is showing some significant reductions as a result of continued curtailments in military activities and of automation of certain functions; increases that occur reflect higher costs for maintaining and operating the data processing equipment, for expanding the U.S. Navy radar program, and for increasing the capability to provide weather support to Air Force tactical operations. The FY 1972 program to expand the administrative facilities at the AFGWC has been deleted while the program to construct new facilities for the FNWC, unfunded in FY 1972, has been programmed for FY 1973.

RESEARCH PROGRAM FOR FY 1973

All military research programs are designed to meet the unique requirements of the Department of Defense. Other Government agencies benefit from this research. The Department's research programs have been categorized and discussed under previous subsections of the Plan as research directed

GENERAL MILITARY METEOROLOGICAL SERVICE, BY AGENCY

	Operations		Supporting research		Total	
	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73
Defense:.....	(29,751)	(25,307)	(10,432)	(9,770)	(40,183)	(35,077)
Army.....	8,545	5,883	9,000	8,361	17,545	14,244
Navy.....	4,877	5,030	782	809	5,659	5,839
Air Force.....	16,329	14,394	650	600	16,979	14,994
Total.....	29,751	25,307	10,432	9,770	40,183	35,077

toward improvements in a specific Service (e.g., Aviation Meteorological Service). These programs are also considered as research in support of the General Military Meteorological Service because they are directed toward improvements in meteorological support to the overall Defense mission.

The specific objectives of the Department in meteorological research include the following:

- ☐ Improvement of the means for meteorological data management, including the collection, dissemination, evaluation, processing, storage, retrieval, display, and quality control of meteorological data and the processing of static data into meaningful and necessary predictions of meteorological conditions.
- ☐ Provisions for near real-time meteorological support to weapon systems and tactical operations by the development of new systems such as the Meteorological Data Sounding System AN/UMQ-7(V) and the Mobile Weather Radar Set AN/TPS-41. Development of a method to organize, integrate, and make available the data of many meteorological observations now taken in the battle area.
- ☐ Identification of the impact of environmental conditions on weapons systems and military operations.
- ☐ Determination of the atmospheric effects on transmission, refraction, and scattering of acoustic and electromagnetic energy and on dissemination of aerosols and radioactive fallout.
- ☐ Rapid conversion of meteorological information into such terms as may be useful to, or required by, operational commanders or be useful in the operation of weapons systems.
- ☐ Improvement of weather observation, analysis, and prediction. Automatic observing and reporting systems for rapid, accurate observa-

tions of meteorological parameters are required. Improvements are also necessary in the unique observation equipment to support land- and sea-based aircraft operations. Computerized systems for analyzing data and for providing accurate long-range weather predictions are required for all regions of the earth. Particular emphasis is placed on extending the present capabilities of prediction to the Tropics, Arctic regions, and the Southern Hemisphere as well as local weather forecasts.

- ☐ Development of techniques and methods by which observations from mesoscale surface networks may be used to increase the accuracy of terminal forecasts.

AIR POLLUTION CONTROL METEOROLOGICAL SERVICE

DESCRIPTION

The high degree of urbanization in the United States is emphasized by the fact that over 70 percent of the people live in some 200 urban areas comprising less than 10 percent of the land area of the country. The requirement to solve the rapidly developing air pollution problem associated with urbanization demands the coordinated efforts of Federal, State, and local governmental activities. The Air Pollution Control Meteorological Service provides essential meteorological data and forecasting to Federal, State, and local governmental agencies responsible for solving air pollution problems confronting the urban areas of the United States and advises the public of weather conditions that may lead to serious air pollution episodes. The Department of Commerce is responsible for providing this Service which includes: surface and upper air observations necessary to describe the weather in urban areas, particularly on the mesoscale; air pollution weather forecasts on both the synoptic-scale

and mesoscale to support air pollution control decisions; and applied research to improve these observations and forecasts. This responsibility is carried out in NOAA by its Air Pollution Weather Service that consists of 43 Air Stagnation Advisory Offices, 14 of which have Environmental Meteorological Support Units (EMSU), and six offices that provide smoke management meteorological support advisory service.

The Environmental Protection Agency (EPA) is responsible for working with State and local governmental agencies to assure that adequate meteorological support programs are implemented. The objective of the Air Pollution Control Meteorological Service is to provide those services which will assist the air pollution control agencies in attaining their common goal of protecting the public safety and welfare against the environmental hazards of air pollution. The specifics of these services are presented in the *Federal Plan for Air Pollution Control Meteorological Service* to support Federal, State, and local air pollution control agencies, published by the Federal Coordinator for Meteorological Services and Supporting Research.

In addition, Commerce monitors the long-term global trends in atmospheric constituents and properties likely to produce climatic change.

OPERATIONAL PROGRAM FOR FY 1973

The operational program of the Air Pollution Control Meteorological Service for FY 1973 reflects an increase of \$735,000 over FY 1972. The major portion of this increase stems from the Department of Commerce program, with support from EPA, to establish and operate EMSUs as indicated in the *Federal Plan for Air Pollution Control Meteorological Service*. Commerce plans to take over the funding of the operation of the EMSUs at Portland, Oreg., and Charleston, W.Va., from EPA, upgrade the equipment at those two locations, and to establish and operate an EMSU at Birmingham, Ala.

RESEARCH PROGRAM FOR 1973

NOAA assigns personnel to the Division of Meteorology, EPA, which conducts a broad research program in air pollution meteorology. This program, which includes both in-house and contract research, has four main themes:

- ☐ Numerical and physical simulation modeling of atmospheric transport, diffusion, and transformation of air pollutants;
- ☐ Effects of air pollutants on weather and climate;
- ☐ Fate of air pollutants as determined by atmospheric removal processes; and

- ☐ Production of climatological information that is descriptive of atmospheric transport, diffusion, and transformation processes.

The modeling research includes not only theoretical computer-based simulations and physical (scale) modeling, but also experimental field programs designed to furnish the data needed to evaluate and further refine the theoretical models. Such models provide a mathematical description of the relations between the patterns and the magnitudes of air pollutant emissions on the one hand and the distribution of the resultant air pollutant concentrations on the other. Thus, the models can be used to determine the source emissions controls necessary to bring the air quality throughout a city or region within the required standard.

Although currently used models are frequently relatively simple in the meteorological sense, research efforts are well underway to develop and to evaluate sophisticated models which include such complexities as photochemical reactions and topographical influences. These advanced models will be used where additional realism is required for application to cities in complex settings.

Modeling is also in progress for predicting pollutant concentrations from large point sources, such as powerplants with tall stacks. This work is being aided by the results from a recent extensive field study around three large powerplants in western Pennsylvania. Considerable attention is being given to determine how sulfur dioxide is removed from plumes by rain or snow.

Effects on weather and climate are being studied in a field program that is designed to assess differences in the radiation budgets of a city and a nearby rural location. On a much larger scale, the national turbidity network, developed by the Division of Meteorology, is being altered to generate data at about 50 locations distributed worldwide. This international network will use an improved dual wavelength instrument. In addition, the feasibility of using satellites to measure pollutant concentrations, turbidity, and albedo are being supported.

Information on atmospheric transport and diffusion are being generated, interpreted, and disseminated for use in modeling and in appraisals of air pollution climatology. The current effort is centered on climatological data pertinent to diffusion from tall stacks.

Other EPA research projects include the development of an operational remote-sensing radiometer for measuring vertical-temperature profiles and the perfection of acoustic-sounding techniques for deriving profiles of wind and turbulence within the

AIR POLLUTION CONTROL METEOROLOGICAL SERVICE, BY AGENCY

	Operations		Supporting research		Total	
	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73
EPA.....	865	1,300	2,925	2,945	3,790	4,245
Commerce.....	1,459	1,759	82	82	1,541	1,841
NASA.....			650	850	650	850
Total.....	2,324	3,059	3,657	3,877	5,981	6,936

planetary-boundary layer.

A number of tasks have been developed at NASA for meteorological satellites and for earth resources surveys that have application in the air pollution field. In addition to these ongoing tasks, NASA is pursuing work on remote measurements of air pollutants. The objective of this work is to develop techniques and systems for the remote detection and measurement of atmospheric pollutants for aircraft and orbital spacecraft. Nondispersive radiometric sensors for use in aircraft or satellites are being developed to verify promising sensing technique for carbon monoxide and will be expanded for flight measurements of other gaseous atmospheric pollutants. Ground measurements of the spectral characteristics of highly polluted urban atmospheres are being obtained from a mobile van containing an infrared monochrometer that views the sun's spectrum through a long atmospheric path. The development of instrumentation and technology will provide the basic design information for satellite systems to monitor air pollution levels and to provide data on temporal and spatial distributions of pollutants that are needed to permit development of analytical models, to predict pollution levels, and to establish pollution controls.

Commerce is planning to procure, install, and test at the Mauna Loa Observatory in Hawaii a prototype of Lidar (light detecting and ranging) equipment to measure the vertical distribution of particulates in the atmosphere and to conduct research that refines observing techniques.

OTHER SPECIALIZED METEOROLOGICAL SERVICES

DESCRIPTION

There are several Federal agencies and user groups whose needs for Other Specialized Meteorological Services, though vital to their missions, are small in relation to the specific Specialized Services discussed in earlier subsections. In general, these requirements relate either to supporting weather services for research and development activities or

for operational activities not large enough to warrant a separate service category. These meteorological service programs generally support stable, ongoing activities; year-to-year changes are small in most cases. The programs included are:

- ☐ The Department of Defense programs for meteorological support to civil works projects and to some of its research, development, test, and evaluation activities such as equipment design and testing, geophysical laboratories support, and polar research operations.
- ☐ The Atomic Energy Commission (AEC) programs for meteorological support to its laboratories and test sites.

OPERATIONAL PROGRAM FOR FY 1973

The Other Specialized Meteorological Services support relatively stable ongoing programs and so annual changes are relatively small.

RESEARCH PROGRAM FOR FY 1973

The AEC research program includes an important element which provides support for a large, changing operational program. This support consists of the evaluation and prediction of atmospheric transport and diffusion and of atmospheric cleansing mechanisms such as deposition and wash-out.

Supporting research for reactor tests includes studies of mesometeorological motions and dilution patterns predicted by a mathematical model and verified with tracer experiment. The motion and dilution of effluents in the immediate wake of large structures are evaluated with field and wind tunnel tests.

The evaluation of safety aspects associated with the transport and storage of nuclear supply systems for space missions requires studies of the movement and composition of aerosols and gaseous radioactive materials extending from the earth's surface to orbital reentry altitudes.

Measurements and supporting studies are necessary to assess the environmental impact of numerous postulated Commission experiments, including

OTHER SPECIALIZED METEOROLOGICAL SERVICES, BY AGENCY

	Operations		Supporting research		Total	
	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73
AEC.....	1,358	1,391	690	700	2,048	2,091
Commerce.....			254	254	254	254
Defense:.....	(9,364)	(9,523)			(9,364)	(9,523)
Army.....	200	230			200	230
Navy.....	1,742	2,095			1,742	2,095
Air Force.....	7,422	7,198			7,422	7,198
Total.....	10,722	10,914	944	954	11,666	11,868

underground tests of nuclear devices and atmospheric tests of nuclear rockets. Recent studies have isolated the individual contributions from various aspects of these tests; test-planning activities have been supported by the development of computerized estimation techniques. Meteorological data collections are performed to permit the assessment of the effect of these variables on the relocation of aerosols previously deposited on the ground surface. A broad variety of modeling is accomplished for application to studies on the long-range effects of various peaceful uses of nuclear explosives.

CLIMATOLOGY

Climatology, part of the Basic Meteorological Service, contributes to the protection of life and property, economic development, and long-range planning through the continuing use of historical weather data to improve knowledge of weather and its effects upon our activities. This subsection discusses the climatological service programs as an entity.

Collection, quality control, analysis, interpretation, storage, application, and retrieval of past meteorological data are fundamental parts of climatological programs. Numerous governmental and private agencies use climatology in their mission-oriented research, studies, and planning. National efforts to store and to process climatological data have been consolidated in a joint civil-military complex, the National Climatic Center (NCC), at Asheville. At NCC, the Department of Commerce discharges its basic responsibility for archiving all meteorological data, for providing quality control of civil data, and for processing data to meet civil requirements. The Department of Defense also contributes meteorological data and performs a portion of its quality control and climatological processing at this location. Defense and Commerce share the use of a joint computer system at Asheville for data processing; Defense also contracts some of its processing and quality control to Commerce.

Operation of the NCC is basic to the Commerce program conducted by its Environmental Data Service. Special requirements for climatological observations are met through the operation of a modest network of climatological reference stations and the support to a large network of cooperative substations. Services include: publication and distribution of data and summaries designed to satisfy large user groups; information services responsive to meet inquiries and requests for special information; processing data to fulfill unique user specifications; and supporting research to improve understanding of climate and its application to user affairs and to develop more effective services. The Department also operates a field service program, providing a climatologist in substantially every State to develop and assist with programs in local applications through cooperation with State and local governments. The Weather Service Offices provide additional contact points for local climatological service.

The U.S. Air Force Environmental Technical Applications Center (ETAC) provides climatological services to the U.S. Air Force and U.S. Army and makes its data available to qualified users in the Department of Defense and other agencies in the Government. The Air Force Global Weather Central (AFGWC) provides near real-time collection of data from the Automated Weather Network. Data are shipped to ETAC on magnetic tape for climatological purposes. The Data Processing Division of ETAC at Asheville further processes Air Force meteorological records for storage and provides retrieval and processing for special military requirements. Commerce and Defense share completely records and facilities maintained at Asheville. Field climatological units and staff meteorologists provide tailored services to military

users, using support of centralized facilities for fast, flexible response to individual environmental problems met by military planners.

Some Defense climatological needs are served by Commerce at NCC on a contract basis. The Defense program at NCC includes such functions as quality control, conversion of data to machine-processable form, and processing of these data to produce marine climatic atlases and studies that meet specific requirements. The NCC performs these functions on a reimbursable basis and, as the responsible Federal agency, provides for archival of data for general use. Defense also provides funding for the acquisition of otherwise unavailable foreign marine data on a global basis. Unclassified climatological publications and data are made available routinely to other Federal agencies and to the public through established channels. Special analyses required to solve individual problems are an increasing portion of this requirement.

Military command and control systems increasingly stress the need for immediate access to selected climatological parameters on a global basis. Defense has committed substantial resources to this long-term task and is compiling special summaries for about 5,000 airfields worldwide. The project involves exhaustive data searching, manual punching, and computer editing, processing, and printing of reports. There is also a continuing project to convert these data to tabular form. These data are available to the public through the National Technical Information Service (NTIS) of Commerce at Springfield, Va. The NCC joint-use computer system at Asheville enables both the Departments of Commerce and Defense to exploit the capability of large-capacity mass-memory files. This system provides immediate access to a large amount of frequently used data retrieved by either date or location. Selected data are also maintained in the processing systems at AFGWC and the Fleet Numerical Weather Central as necessary to support their operational systems.

Many other Federal agencies use weather records or climatology in internal studies, research, or plan-

ning without identifying a specific climatological program or function. Examples are the evaluation and analyses of water resources by the Department of the Interior and the research and planning involved in weather crop relations by the Department of Agriculture. The Department of Health, Education, and Welfare, and now EPA, have supported development of a national air pollution potential climatology. Support will be continued for the observation, storage, and processing of meteorological parameters affecting the incidence, transport, and dissipation of air pollution. The relevance of climatic factors to such problems as waste accumulation, housing, accidents, and disease vectors is also recognized. The research by AEC on the probable fate of radioactive contaminants released into the atmosphere uses climatology. NASA observes and studies fine-scale features for application to aerospace vehicle design and operation. The National Science Foundation sponsors some research in climatology and recognizes that climatological service is a supporting requirement for much ongoing meteorological research.

Technological advances require corresponding advances from climatology's traditional supporting role. Traditional user activities are subject to increasingly precise analysis and design for improved reliability, economy, and effectiveness; new areas such as exploitation of space, development of marine resources, and understanding of man's interaction with his environment require attention. This shift into new activities has been reflected in the necessity to create additional environmental data centers to supplement the original NCC; for example, the National Oceanographic Data Center, Aeronomy and Space Data Center, National Space Science Data Center, and Geophysical Air Quality Data Bank. Climatological requirements frequently enter these associated areas and such purely meteorological areas as fine-scale composition, structure, motion, and variations in the atmosphere and their associated physical, optical, and electromagnetic effects. It is increasingly necessary for the climatological services to develop related bases for support.

Operational Functions

INTRODUCTION

Five distinct functions are common to all Basic and Specialized Meteorological Services. These are observations, analyses and forecasts, communications, dissemination to users, and general agency support. A description of the total Federal operations for each of these functions is presented in this section of the Plan. Following the description of each of the functions, the program changes for FY 1973 as projected by the agencies to meet the Federal goals are presented.

OBSERVATIONS

DESCRIPTION

Five general categories of observations constitute the basic function supporting the Federal meteorological services. These five categories—surface, upper air (balloon and rocket), aircraft reconnaissance, weather radar, and weather satellite systems—are described in greater detail in the following paragraphs of this subsection of the Plan.

Surface Observations

Federal agencies take surface weather observations at approximately 1,100 locations to support basic analysis and forecasting and certain specialized services. This effort does not include the approximately 13,000 cooperative observation stations manned by volunteers and the cooperative observation networks that support agriculture and fire-weather observations in the 50 States, Puerto Rico, and territories and possessions. In addition, Federal agencies either take or support observations made on many ships at sea and at a limited number of locations within other countries. The U.S. effort is supplemented with surface observations by other nations so that a global network of observations is available for analysis and prognosis by processing centers in this country and in all other countries concerned.

Upper Air Observations

The Basic Upper Air Observation Network pro-

vides upper air observations for numerical analysis and general forecasting. The Network is composed of Department of Commerce stations—supplemented by stations operated on a cooperative basis by Commerce with Canada, Mexico, and Caribbean and Latin American countries—and other Federal facilities in the United States and overseas. This Network within the conterminous States is shown on figure 9. In addition, a number of Government ships (Commerce, Defense, and Transportation) and merchant ships with National Weather Service (NWS) personnel aboard make upper air observations; these observations supplement the fixed land stations in the Network by giving minimal data over the oceans.

Upper air observations are also taken, generally on an unscheduled basis, at test ranges and at some research facilities for specialized support and by mobile facilities in support of severe local storms forecasting, military operations and training, and other programs. The developing air pollution control activities of EPA and of State and local control authorities require detailed information on the vertical structure of the atmosphere over urban areas. Low-level upper air observations taken twice daily to about 10,000 feet provide these data and supplement the regular upper air network. These low-level upper air observations are entered on the Service C Teletypewriter System where they can be used effectively by analysis and forecast centers for such functions as severe local storm warnings. The upper air program in this country is supplemented with upper air observations by other nations so that a global network of observations (from approximately 850 stations) is available for analysis and prognosis.

Both NASA and the Department of Defense make extensive use of upper atmospheric data obtained from rocketsondes for supporting their spacecraft launching activities. The centers at Huntsville, Ala., Langley, Va., Houston, Cape

Kennedy, Vandenberg and Edwards Air Force Bases (AFB), Calif., and Wright-Patterson AFB, Ohio, are the prime NASA and Defense users of these data. The rocketsonde network is shown in figure 10.

Commerce monitors long-term global trends in atmospheric constituents and properties likely to produce climatic change. These observations (surface and upper air) are now made at the Mauna Loa Observatory on a routine basis.

Weather Reconnaissance Observations

The Department of Defense aircraft synoptic reconnaissance program provides weather information and meteorological measurements at flight altitude along specific established tracks. Instruments dropped from aircraft provide sounding data from flight altitude to the earth's surface at specified reporting points. Oceanographic information is also obtained on these flights. This method of observation is principally used over large ocean areas where other weather information is sparse or nonexistent. Synoptic reconnaissance flights are

flown at scheduled intervals to provide data for basic analysis and forecasting.

Other reconnaissance flights are made to investigate suspected storm areas and to obtain precise data on the location, movement, and physical characteristics of winter storms off the east coast of the United States and tropical cyclones in the western Atlantic Ocean, Caribbean Sea, Gulf of Mexico, and Pacific Ocean. Procedures for these reconnaissance flights are included in the *National Hurricane Operations Plan* and the *National East Coast Winter Storms Operations Plan*.

Still another type of reconnaissance is conducted in support of specific Defense operations. Special weather reconnaissance observations are provided in support of tactical land, sea, and air operations. These include troop maneuvers, mass airdrops, missile launches and recoveries, fleet exercises, and air refueling operations.

The Department has six WC-135s, 22 WC-130s, four WC-121Ns, and one WP3A aircraft equipped for use in synoptic and special reconnaissance. The WC-121s and the WP3A are equipped with bathy-

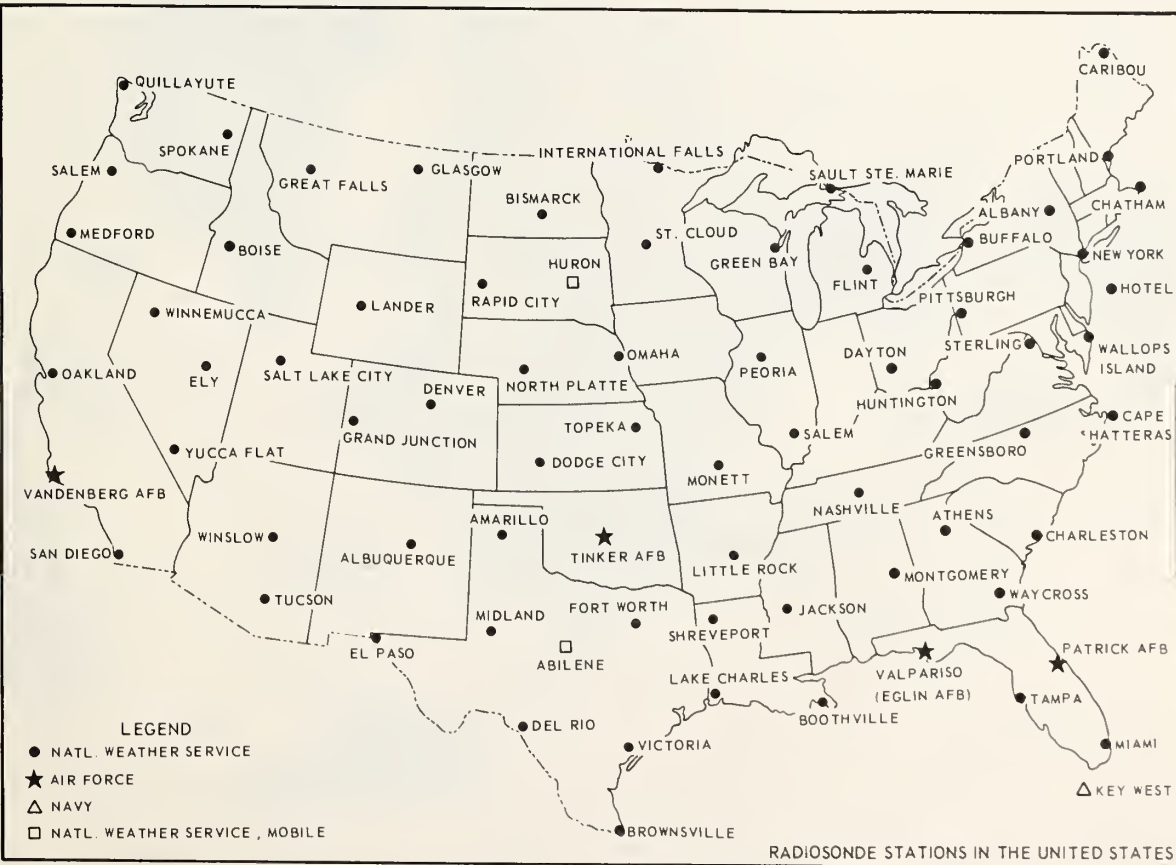


Figure 9. Network of upper air observation stations in the United States.

thermograph equipment for measuring ocean temperatures to a depth of 1,000 feet.

Defense weather reconnaissance efforts are supplemented by data obtained by Department of Commerce research aircraft that gather information on hurricanes in the North Atlantic Ocean, Caribbean Sea, and Gulf of Mexico and on winter storms off the east coast of the United States. The Commerce aircraft—a WC-130 and two DC-6s—funded under research programs, provide supplemental data and reconnaissance backup to the effort made by Defense.

Weather Radar Observations

Radar, one of the principal sources of weather information, is used in preparing vital weather warnings to the public, industry, and Government and in providing observations that protect life and property as well as give control and safety to air-

craft in flight. These observations provide:

- ☐ The best method now available for remote identification and tracking of squall lines, tornadoes, and other destructive storms.
- ☐ A means for locating, tracking, and estimating the intensity of hurricanes as they approach the U.S. coastal areas.
- ☐ The information upon which estimates of precipitation rates and amounts can be based for use in providing flash-flood warnings and in managing water resources within river basins.
- ☐ The detection of probable convective storm turbulence.

There are two general categories of uses or needs for these radar data. The first is "synoptic" and requires systematic observations from a network of radars to give data for input to large-scale meteor-



Figure 10. Network of rocketsonde stations operated by agencies of the Federal Government.

The *Federal Plan for Weather Radars and Remote Displays* identifies the need for local and network weather radar observations and describes a coordinated long-term program to meet these needs most effectively and economically. The Synoptic Weather Radar Network, established in this Plan to make detailed observations on a scheduled basis, uses Department of Commerce and certain Department of Defense weather radars. Air Traffic Control radars of FAA are also used in some Western States to supply limited observations in a region where weather radar installations are extremely ex-

Observations from the radar network in the conterminous States are collected at a central location, compiled, and transmitted over facsimile systems and teletypewriter networks to civil and military weather service offices for use in preparing forecasts, warnings, and pilot briefings beyond the range of their local radar coverage.

Weather Satellite Observations

Increasingly, the satellite is playing an important role, along with more conventional techniques, in producing meteorological data for weather analysis and prognosis, storm warnings, and oceanographic forecasts. The developing national operational environmental satellite system is described in the Weather Satellites section of this Plan.



AGENCY MANPOWER ENGAGED IN WEATHER OPERATIONS, BY FUNCTION

	Observations		Analyses and forecasts		Communications		Dissemination to users		General agency support		Total	
	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73
Commerce.....	1,807 [79]	1,856 [79]	1,617 [43]	1,733 [43]	206 [15]	216 [15]	1,007	1,019	936 [45]	1,021 [45]	5,573 [182]	5,845 [182]
Defense:.....	(4,411)	(3,713)	(1,873)	(1,710)	(1,819)	(1,510)	(3,184)	(3,384)	(4,173)	(3,898)	(15,460)	(14,215)
Army.....	846	490							124	107	970	597
Navy.....	550*	394*	529*	519*	306*	296*	257*	246*	1,053*	1,010*	2,695*	2,465*
Air Force.....	3,015	2,829	1,344	1,191	1,513	1,214	2,927	3,138	2,300 696*	2,045 736*	11,099 696*	10,417 736*
Transportation:.....	(1,632)	(1,644)			(838)	(698)	(718)	(778)	(485)	(485)	(3,673)	(3,605)
Coast Guard.....	1,200*	1,200*			10*	10*	9*	9*	20*	20*	1,239*	1,239*
144	144										144	144
FAA.....	288*	300*			828*	688*	709*	769*	465*	465*	2,290*	2,222*
Total.....	7,929	7,292	3,533	3,486	2,878	2,439	4,909	5,181	5,639	5,449	24,888	23,847

[] Indicates personnel funded by other agencies.

*Indicates man-years of effort. Functions are performed as part-time tasks by personnel assigned to other primary duties. For Coast Guard, includes 40 percent of personnel required to man ships in the Ocean Station Vessel (OSV) program, except for vessels serving ocean station Hotel, for which the apportionment to meteorological services is 100 percent.

AGENCY OPERATIONAL COSTS, BY FUNCTION

	Observations		Analyses and forecasts		Communications		Dissemination to users		General agency support		Total	
	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73
AEC.....	665	682			14	14	95	98	584	597	1,358	1,391
Commerce.....	53,050	58,881	37,201	43,124	7,367	7,877	15,174	15,823	21,382	24,734	134,174	150,439
Defense:.....	(66,223)	(61,187)	(22,487)	(22,257)	(23,426)	(20,535)	(33,321)	(35,131)	(46,576)	(46,606)	(192,033)	(185,986)
Army.....	7,068	4,749					200	230	1,477	1,134	8,745	6,113
Navy.....	7,474	7,784	6,804	7,966	3,802	3,843	3,268	3,203	13,491	13,130	34,839	35,926
Air Force.....	51,681	48,654	15,683	14,561	19,624	16,692	29,853	31,698	31,608	32,342	148,449	143,947
EPA.....	230	450	120	150					515	700	865	1,300
NASA.....	433	325	658	614	42	41	67	76	288	610	1,488	1,666
Transportation:.....	(16,542)	(17,868)			(16,739)	(15,867)	(11,116)	(12,376)	(10,239)	(10,159)	(54,636)	(56,270)
Coast Guard.....	11,708	12,700			127	133	180	335	165	165	12,180	13,333
FAA.....	4,834	5,168			16,612	15,734	10,936	12,041	10,074	9,994	42,456	42,937
Total.....	137,143	139,393	60,466	66,415	47,588	44,334	59,773	63,504	79,584	83,406	384,554	397,052

PROGRAM CHANGES FOR FY 1973

A general curtailment of activities within the Department of Defense, combined with a change in emphasis of other activities, account for the major changes in the Defense FY 1972 programs. The program planned for FY 1972 implementation, involving the purchase and installation of 22 radar-

remoting transmitters and 23 remote receivers at \$1,185,000, is being held in abeyance until further tests and evaluation are completed. Other reductions in FY 1972 include the elimination of the High Altitude Balloon Unit at Goodfellow AFB, Tex., and the reduction from four to two upper air soundings per day at selected locations by the U.S.

AGENCY SUPPORTING RESEARCH COSTS, BY FUNCTION

	Observations		Description		Prediction		Dissemination		Systems		Support		Total	
	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73
Agriculture.....	115	115	642	696	63	68							820	879
AEC.....	345	350	276	280	69	70							690	700
Commerce.....	2,175	2,110	536	536	888	888	175	200	306	256	369	394	4,449	4,384
Defense:.....	(3,884)	(3,541)	(1,712)	(1,700)	(811)	(779)	(138)	(103)	(5,255)	(4,500)	(4,114)	(3,897)	(15,914)	(14,520)
Army.....	2,594	2,281	1,277	1,250	86	44	138	103	955	950	4,114	3,897	9,164	8,525
Navy.....	600	620	435	450	290	300							1,325	1,370
Air Force....	690	640			435	435			4,300	3,550			5,425	4,625
EPA.....	787	795	2,088	2,100	50	50							2,925	2,945
NASA.....	44,770	63,883							1,285	1,900			46,055	64,783
Transportation:..	(1,818)	(2,100)			(342)	(205)	(1,237)	(1,023)	(2,456)	(2,287)			(5,853)	(5,615)
FAA.....	1,818	2,100			342	205	1,237	1,023	2,456	2,287			5,853	5,615
Total.....	53,894	72,894	5,254	5,312	2,223	2,060	1,550	1,326	9,302	8,943	4,483	4,291	76,706	93,826

Air Force at \$1,388,000; a decrease in meteorological reconnaissance by the U.S. Navy in the Pacific at \$4,009,009; and a reduction by the U.S. Army of observation points in Korea and Vietnam at \$892,000. Along with these reductions, the Defense FY 1972 program provides for an increase in support to the Air Force Category II Instrument Landing System with the purchase and installation of two Runway Visual Range (RVR) systems and six Digital Wind Measuring Sets at a total of \$812,000. The Air Force has also programmed the purchase of 15 lightning detectors in FY 1972. Although the Navy is decreasing its overall weather reconnaissance program, improvements are planned to provide more capability for storm reconnaissance in the Atlantic and Caribbean Sea in support of weather disaster warnings through the equipping and modifying of three WP-3A aircraft at \$1,575,000; these modified aircraft will replace four WC-121Ns. The additional WP-3As will also be equipped with bathythermograph equipment for measurements of ocean temperatures to a depth of 1,000 feet. Also in FY 1972, the Navy is buying 500 instrument heads (PWN-8B) for rocketsondes.

In FY 1973, Defense plans further reductions in its overall operational weather reconnaissance effort, leading to a reduction of \$5,361,000. This reduction will be applied to routine reconnaissance and will not affect the reconnaissance of hurricanes, typhoons, and east coast winter storms. The Air Force is modifying its reconnaissance aircraft to provide an increased weather reconnaissance capability at \$2,740,000. In other weather-observing functional areas, the Navy plans the purchase of three parachute-tactical automatic weather stations

at \$100,000, miscellaneous replacement items for automatic and buoy stations at \$300,000, 500 HASP-III rocketsonde systems at \$300,000, three radar sets and 20 radio receivers to equip meteorological vans at \$500,000, three local-use weather radar sets to replace obsolete items at \$460,000, and eight semiautomatic weather stations to provide a local-use observation capability at Naval and Marine Corps Air Stations at \$200,000. The Navy also plans to convert 50 RVRs located at Naval and Marine Corps Air Stations to provide visibility information for landing aircraft at \$100,000. The Air Force plans to purchase and install 30 lightning detectors at \$360,000. The Air Force is also reflecting a decrease in costs of \$2,108,000 as a result of reduction in personnel and facilities.

The Department of Commerce in FY 1973 has an extensive program to improve its capabilities in four of the five weather-observing categories. In the surface-observing category, Commerce plans to acquire 24 Automatic Meteorological Observing Stations (AMOS III-70) to fill gaps in observing networks, to replace previously manned sites lost by automation, and to replace obsolete equipment at \$720,000. The Department plans to supply contractual services at 20 other observing sites that are not to be manned and for which automatic stations will not be initially available, at \$405,000. To acquire selected weather information rapidly by using the Geostationary Operational Environmental Satellite (GOES) communications relay capability, Commerce plans to obtain interface and radio-receiving equipment for two ships and for those AMOSs at \$40,000.

In the upper air observations program, the De-

AGENCY OPERATIONAL COSTS, BY TYPE OF OBSERVATION

	Surface		Upper air (balloon)		Upper air (rocket)		Weather reconnaissance		Weather radar		Weather satellite		Total	
	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73
AEC.....	243	250	422	432									655	682
Commerce....	13,573	14,796	14,471	16,127					4,586	4,794	20,420	23,164	53,050	58,881
Defense:....	(12,392)	(9,963)	(9,411)	(6,650)	(2,165)	(2,118)	(40,395)	(39,718)	(491)	(1,322)	(1,369)	(1,416)	(66,223)	(61,187)
Army.....			7,068	4,749									7,068	4,749
Navy.....	2,604	3,621	320	359	346	351	2,864	1,076	183	1,165	1,157	1,212	7,474	7,784
Air Force..	9,788	6,342	2,023	1,542	1,819	1,767	37,531	38,642	308	157	212	204	51,681	48,654
EPA.....			230	450									230	450
NASA.....	83	104	183	155	91	28	19	35			57	3	433	325
Transporta- tion:....	(7,176)	(7,708)	(9,366)	(10,160)									(16,542)	(17,868)
Coast Guard....	2,342	2,540	9,366	10,160									11,708	12,700
FAA.....	4,834	5,168											4,834	5,168
Total.....	33,467	32,821	34,083	33,974	2,256	2,146	40,414	39,753	5,077	6,116	21,846	24,583	137,143	139,393

SURFACE OBSERVATIONS (Land stations)

Agency	Locations	
	FY 72	FY 73
Department of Commerce*	466	511
Department of Defense.....	301	280
Department of Transportation (FAA).....	346	358
National Aeronautics and Space Administration....	3	3
Atomic Energy Commission.....	2	2

*Cooperative stations operated by Departments of Agriculture, the Interior, and Transportation, other public and private agencies, and those manned by volunteers are not included. Also excluded are 272 Supplementary Aviation Weather Reporting Stations and foreign cooperative stations included in previous plans.

WEATHER RADAR OBSERVATIONS

Agency	Locations	
	FY 72	FY 73
Department of Commerce (U.S.).....	50	51
Department of Defense (U.S.).....	93	95
Department of Defense (Overseas).....	39	37
National Aeronautics and Space Administration (U.S.).....	2	2

UPPER AIR OBSERVATIONS (Balloon)

Agency	Locations	
	FY 72	FY 73
Department of Commerce (U.S.).....	104	106
Department of Commerce (Overseas).....	40	38
Department of Commerce (Ship).....	15	15
Department of Defense (U.S.).....	7	7
Department of Defense (Overseas).....	19	17
Department of Defense (Ship).....	36	33
Department of Defense (Mobile).....	18	18
National Aeronautics and Space Administration (U.S.).....	3	3
Atomic Energy Commission (U.S.).....	2	2
Departments of Commerce and Transportation (Ocean Stations)*.....	7	6

*Department of Transportation (Coast Guard) has 33 vessels equipped for upper air observations. These support the ocean station vessel programs and other activities as required.

SURFACE OBSERVATIONS (Marine)

Agency	Locations	
	FY 72	FY 73
Department of Commerce (Moving Vessels with Meteorological Personnel).....	15	15
Department of Commerce (Merchant Ships Coopera- tive Program).....	2,305	2,305
Department of Transportation (Coast Guard)*.....	279	270
Department of Defense (Ships with Meteorological Personnel).....	38	33
Departments of Commerce and Transportation (Ocean Stations).....	7	6

*Includes 107 ships and 163 shore stations supporting marine activities.

partment is improving its services in FY 1973 by expanding automated observations through the use of on-station computers at \$420,000. In support of the Air Pollution Control Meteorological Service, the Department of Commerce plans to acquire low-level upper air sounding units for Birmingham, Ala., Charleston, W. Va., and Portland, Oreg., at \$180,000.

The upper air station at Kodiak, Alaska, provides data in support of the Basic Meteorological Service and, consequently, is a responsibility of Commerce. Negotiations are taking place for Commerce to accept this facility and function from Defense in FY 1973 at an added cost to Commerce of \$200,000.

In the radar-observing category, negotiations are underway for Commerce to take over the WSR-57 radar now operated by Defense at Pensacola, Fla., at \$147,000. Previously, WSR-57s have been transferred from Defense to Commerce at Brunswick, Maine, Memphis, Tenn., and Quonset Point, R.I.

The satellite-observing programs are included in a separate section of this Plan on Weather Satellites. In addition to those programs, Commerce plans to purchase seven small photographic display units for its Weather Service Forecast Offices and to operate and maintain these units along with others available in conjunction with the current operational satellite system at \$342,000. In addition, Commerce is planning to purchase five high-quality display devices capable of receiving sectorized

GOES pictures, to interpret data for forecasts and warnings, and to operate and maintain the equipment at \$280,000. The Defense program in FY 1973 provides for the purchase of 10 automatic picture transmission photorecorders at \$200,000, for the conversion of 10 shipboard antennas and receivers to use GOES-relayed transmissions at \$175,000, and for the establishment of 13 GOES/facsimile display stations at \$325,000.

The FAA in FY 1972 is procuring and installing 10 RVR equipment at \$429,000. In FY 1973, the FAA plans to procure and install 9 RVRs and 11 rotating-beam ceilometers at \$619,000. These programs include those planned for FY 1971, but were not funded, and are part of the FAA's continuing program to automate observing equipment and to provide lower landing minimums at Category I and II airports. The Coast Guard increase of approximately one million dollars is attributed to increases in pay and costs of other support services.

ANALYSES AND FORECASTS

DESCRIPTION

There are three major types of analysis and forecast centers: primary, area and guidance, and specialized. Primary centers produce basic analyses and forecasts and provide basic warning services. Area and guidance centers supplement the products of primary centers and adapt them to their particular regions. Specialized centers serve the unique requirements of specific user groups or provide a service not available from other centers such as fire-weather support.

Primary Centers

The Department of Commerce operates four primary centers. The NOAA National Meteorological Center (NMC) at Suitland provides basic weather analyses and forecasts for the Northern Hemisphere and for portions of the Southern Hemisphere. The NMC has also been designated as one of three World Meteorological Centers and thus is assigned global responsibilities for analyses and forecasts under an international program—the World Weather Watch. During a typical day, NMC processes more than 40,000 surface observations, 2,000 ship reports, 1,500 upper air soundings, 2,800 aircraft reports, and global cloud-cover data from weather satellites. Products of NMC include more than 500 facsimile and 200 teletypewriter transmissions daily to its users primarily in North America, but also in overseas areas.

The NOAA National Hurricane Center (NHC) and the Regional Center for Tropical Meteorology (RCTM) are operated in Miami by Commerce.

WEATHER RECONNAISSANCE

Agency	Number of Aircraft Years	
	FY 72	FY 73
Department of Defense (Navy).....	5	3
Department of Defense (Air Force).....	34	29

UPPER AIR OBSERVATIONS (Rocket)

Agency	Locations	
	FY 72	FY 73
National Aeronautics and Space Administration (U.S.).....	1	1
National Aeronautics and Space Administration (Overseas).....	1	1
Department of Defense (U.S.).....	5	5
Department of Defense (Overseas).....	11	11
Atomic Energy Commission (U.S.)*.....	1	1
Atomic Energy Commission (Overseas)*.....	2	2

*No operational funds programmed.

The NHC provides basic forecasts and warnings of hurricanes in the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico for all Federal agencies and user groups. The RCTM, designated by the World Meteorological Organization as a part of the World Weather Watch, produces basic analysis and forecast information for the tropical latitudes, supplementing the mid- and high-latitude products of NMC.

The NOAA National Severe Storms Forecast Center (NSSFC), operated at Kansas City by Commerce, provides forecasts and warnings of severe local storms (including tornadoes) for the general public and most Federal agencies. A continuous watch of weather developments in the conterminous States is maintained, and alerts are issued by NSSFC when needed.

The Department's responsibility for establishing and operating a national operational environmental satellite system is fulfilled by the NOAA National Environmental Satellite Service (NESS) at Suitland. The NESS, in addition to managing all operational meteorological satellite operations, processes data from both operational and research and development meteorological satellites to provide outputs required by civil and military users. The resulting products have made significant contributions to forecasts and warnings of hurricanes and other major severe storms by providing information on their existence and intensity in those areas where conventional observations are sparse or nonexistent.

The Department of Defense operates two primary centers. The Air Force Global Weather Central (AFGWC) at Offutt AFB provides basic analysis and forecast products in support of worldwide Defense aerospace operations. Products from AFGWC are distributed to globally dispersed Defense facilities and forces by facsimile, teletypewriter, and high-speed communications systems. The Navy Fleet Numerical Weather Central (FNWC) at Monterey provides basic analysis and forecast products for the Northern Hemisphere in support of naval requirements. Products from FNWC are disseminated over the Naval Environmental Data Network to Fleet Weather Centrals and Facilities located strategically throughout the world and to naval ships through interlinking fleet facsimile and teletypewriter broadcasts. The recent advent of high-speed data link communications has made it technologically possible and economically advantageous for direct computer-to-computer exchanges of products among Defense processing centers.

The threat of power shortages or failures along the eastern seaboard places in jeopardy the capability

of NMC to provide basic weather analyses and forecasts. A *Federal Plan for Cooperative Backup Among Operational Processing Centers* has been developed to provide for continuous service in the event of such a contingency. According to this Plan, should NMC become incapacitated because of a power or computer failure, AFGWC will provide selected essential meteorological charts for entry on the National Facsimile Network (NAFAX) at Kansas City.

Area and Guidance Centers

Area and guidance centers form the intermediate level in the weather analysis and forecasting structure. These centers, using the products of primary centers, are responsible for forecasts and warnings within their assigned areas. They also provide detailed guidance and support to civil or military weather service offices within their areas.

The Department of Commerce operates 42 area and guidance centers in the United States and one in Puerto Rico. Each center provides forecasts and warnings for one or more States or for large portions of one State for periods up to 48 hours. Short-period warnings on hazardous weather situations are issued to the general public by all NOAA Weather Service Offices (WSO).

The Department of Defense operates 8 area and guidance centers in the United States and 9 in overseas areas to meet its global military requirements. These centers are uniquely oriented to support military operations.

Specialized Centers

Specialized centers meet the unique requirements of a specific user group. Center personnel are trained in special areas such as agricultural, marine, and aviation meteorology so that they can better understand and meet the user needs.

The Department of Commerce has specialized centers to serve aviation, agriculture, air pollution control, and fire-weather activities. Personnel for these specialized centers are usually collocated within large-area centers, producing information for their particular user groups. Additionally, with funding support from NASA, Commerce provides small but highly specialized centers to support the space program at various locations in the United States. These four centers supporting the manned spaceflight program are further supplemented by teams at three major NOAA National Weather Service (NWS) facilities. The NOAA National Climatic Center (NCC) at Asheville is the central archival, processing, and service center for weather records collected by all Federal agencies.

The Department of Defense agencies operate

AGENCY OPERATIONAL COSTS, BY TYPE OF CENTER

	Primary		Area and guidance		Specialized		Total	
	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73
Commerce.....	17,015	21,113	9,262	9,459	10,924	12,552	37,201	43,124
Defense:.....	(9,601)	(11,181)	(8,179)	(6,277)	(4,707)	(5,069)	(22,487)	(22,527)
Navy.....	1,600	2,931	5,014	4,835	190	200	6,804	7,966
Air Force.....	8,001	8,250	3,165	1,442	4,517	4,869	15,683	14,561
EPA.....					120	150	120	150
NASA.....					658	614	658	614
Total.....	26,616	32,294	17,441	15,736	16,409	18,385	60,466	66,415

two specialized centers in the United States and one overseas to provide support to unique military needs.

PROGRAM CHANGES FOR FY 1973

The analyses and forecasts function is performed in all three major types of centers—primary, area and guidance, and specialized. The following paragraphs highlight the program changes in this function. The accompanying table lists the total operational costs, by agency, for these three types of centers for FY 1972 and FY 1973.

In support of the long-term goals of the Federal meteorological services, the Department of Commerce, through the NWS of NOAA, is engaged in a strong program to improve its forecasting capabilities and services. Within this broad objective, Commerce fulfills its obligations, as expressed in the *Federal Plan for Air Pollution Control Meteorological Service*, by establishing and operating Environmental Meteorological Support Units (EMSU) in urban areas to support the Air Quality Control Regional Programs of EPA. Two EMSUs scheduled for operation in FY 1972, Portland, Oreg., and Charleston, W. Va., have been delayed until FY 1973. One more EMSUs is scheduled to be established and operated in FY 1973 at Birmingham. The additional cost for the three locations above amounts to \$300,000.

Commerce is taking a number of actions in a major effort to improve its Specialized Meteorological Services to various users. In the agricultural weather area, a forecaster is being added to the staff at the Weather Service Forecast Office (WSFO) in Salt Lake City in FY 1972 at \$20,000; in FY 1973, Commerce plans to implement the Agricultural Weather Service programs in Arizona, Montana, Nebraska, New York, North Carolina, Ohio, and Wyoming and to augment the same Service in California and Oregon for an increase of

\$420,000. A Marine Forecast Office is to be established at San Francisco; marine specialists are to be added to Offices in Detroit, Honolulu, New Orleans, Miami, Silver Spring, Md., and Washington, D.C., for an increase of \$229,000. Also in the marine weather forecasting area, NMC plans to provide Marine Forecast Offices with graphical guidance products, both analyses and forecasts, that will indicate wind, waves, visibility, weather, and ice at an increase of \$76,000. Commerce will also upgrade the WSOs at Phoenix, Ariz., Boise, Idaho, Indianapolis, Ind., and Des Moines, Iowa, at an increase of \$300,000.

Commerce plans to modernize its NCC by instituting a rapid response system for all available environmental data and sources and to compress active document files into a permanent, safe microfiche medium at \$175,000. Commerce improvements for NMC include providing computer costs for the development of methods for assimilating satellite data into numerical models and for testing of models before implementation at \$800,000.

The Department of Defense will provide increases in FY 1973 to support the increased cost of leasing and maintaining the automated data processing equipment at its AFGWC and to support its climatology operations at NCC in Asheville at \$360,000.

COMMUNICATIONS

DESCRIPTION

Communications facilities for meteorological operations are used to collect the vast amount of weather data for centralized processing and for direct application to many user groups. Weather communications facilities are also used to distribute information from processing centers and civil and military weather service offices to the public and to various specialized users. Demands for service cre-

ated by the increasing range and speed of modern aircraft require the collection and exchange of observations from most areas of the world for operational uses and for inputs to the analysis and forecasting routines at weather centers.

For more than 40 years, teletypewriter systems have been the principal means for collecting and distributing observations and forecasts. Facsimile systems are widely used to distribute weather maps and other products from weather centers. Demands for increased amounts of data, greater collection speed, and more products from computers in weather centers have led Federal agencies to increase their use of high-speed digital systems as replacements for some teletypewriter and facsimile networks. High-speed data transfer is generally accomplished by computer-to-computer links.

The major communications systems in use are described in the following paragraphs.

Teletypewriter and High-Speed Systems

Federal Aviation Administration

The Modernized Weather Teletypewriter Communications System (MWTCS) consolidates the circuit control and relay functions of Services A, C, and O into a single Weather Message Switching Center (WMSC) at Kansas City. These functions are performed automatically by a group of electronic computers which are combined to operate as a real-time store-and-forward communications switch. All Service A and C circuits extend directly into the WMSC. Certain Service O circuits also extend directly into the computer switch while others, from overseas points, pass through the Aeronautical Fixed Telecommunications Network switch which is collocated and interconnected with the WMSC. Computer-to-computer links provide for the exchange of data between the WMSC and the National Meteorological Center (NMC) at Suitland

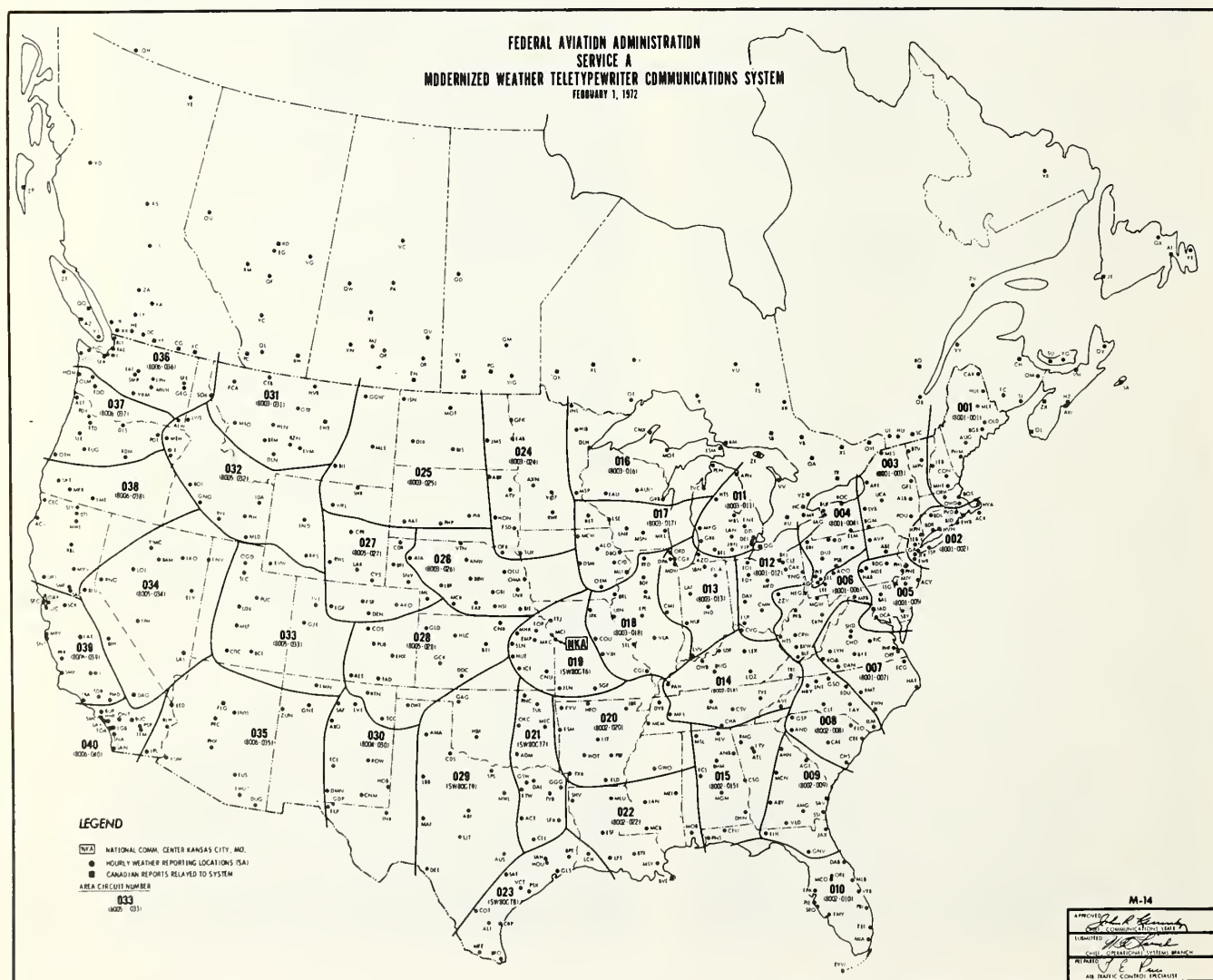


Figure 12. Service A Teletypewriter System.

and between the WMSC and the U.S. Air Force Automated Weather Network (AWN) at Carswell AFB, Tex.

Circuits of the MWTCS are classified and described as follows:

- ☐ *Service A Area Circuits:* Forty 100-wpm (words per minute) multipoint half-duplex circuits which are designed solely to meet the collection and routine distribution requirements of the average FAA and National Weather Service (NWS) user. Other users may obtain receive-only drops on these circuits if their needs are incidentally compatible with those of the FAA and NWS.
- ☐ *Service A Request/Reply Circuits:* Forty 100-wpm half-duplex circuits which parallel the Service A Area Circuits and enable Government flight-briefing facilities to obtain information not routinely transmitted to the associated Area Circuit.
- ☐ *Service A Low-Speed Nongovernmental Circuits:* Fourteen 100-wpm multipoint circuits for the distribution of data to meet the requirements of nongovernment users, principally airlines, whose needs are not satisfied by the Area Circuits.

pally airlines, whose needs are not satisfied by the Area Circuits.

- ☐ *Service C Area Circuits:* Twelve 100-wpm multipoint half-duplex circuits for the collection and distribution of Service C data to serve both Government and nongovernment users.
- ☐ *Service O Area Circuits:* 67- and 100-wpm multipoint half-duplex circuits for the collection and distribution of Service O data to serve both Government and nongovernment users.
- ☐ *Air Force Circuits:* Twenty-one 100-wpm multipoint circuits for the distribution of Service A, C, and O data to high-volume AFBs in the United States whose requirements cannot be satisfied by the use of Area Circuits alone.
- ☐ *Weather Service Forecast Office Point-to-Point Circuits:* Thirty-nine 100-wpm full-duplex circuits to the Weather Service Forecast Offices (WSFO) for transmission of forecast products to the WMSC and receipt by the WSFOs of supplementary weather data.

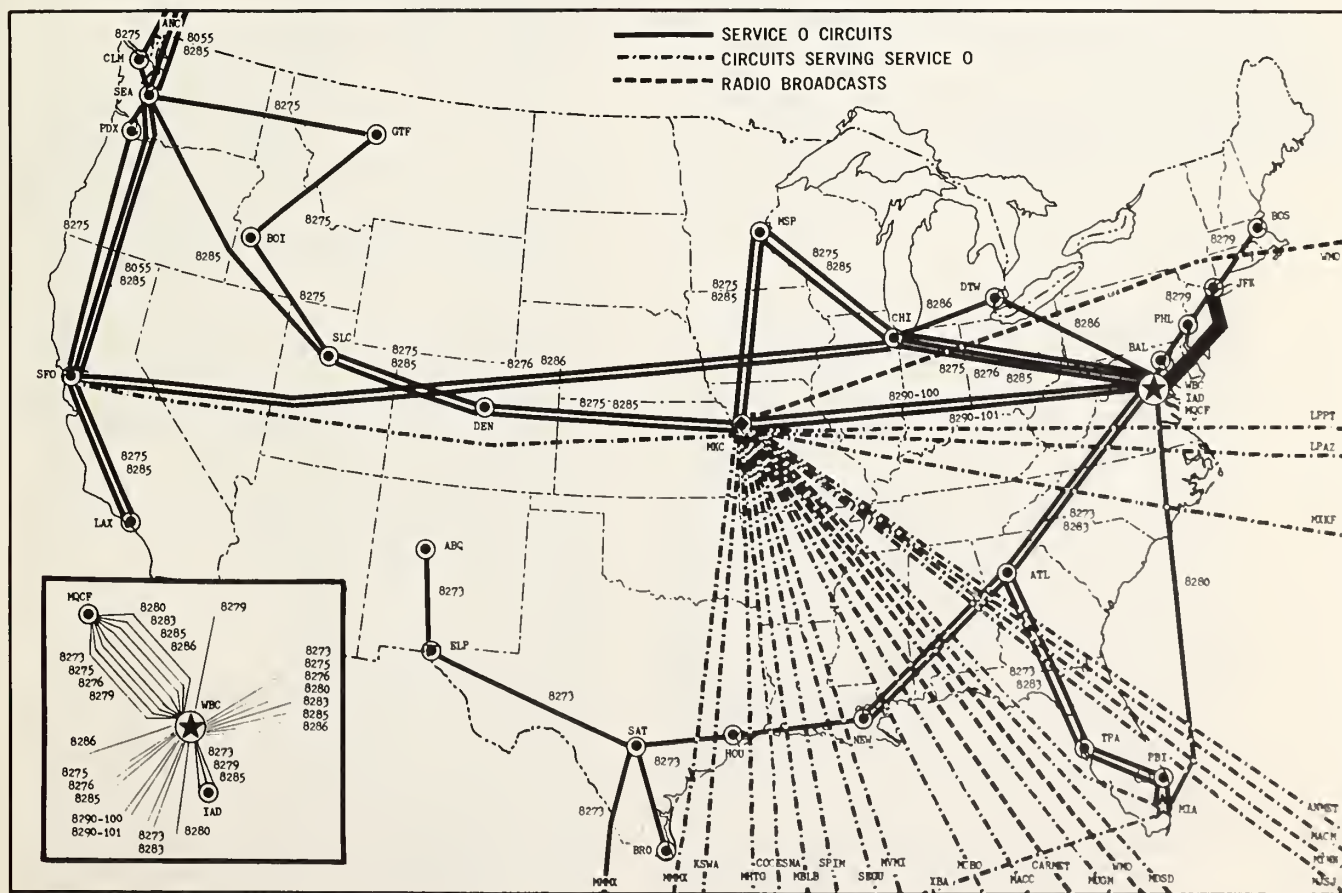


Figure 13. Service O Teletypewriter System.

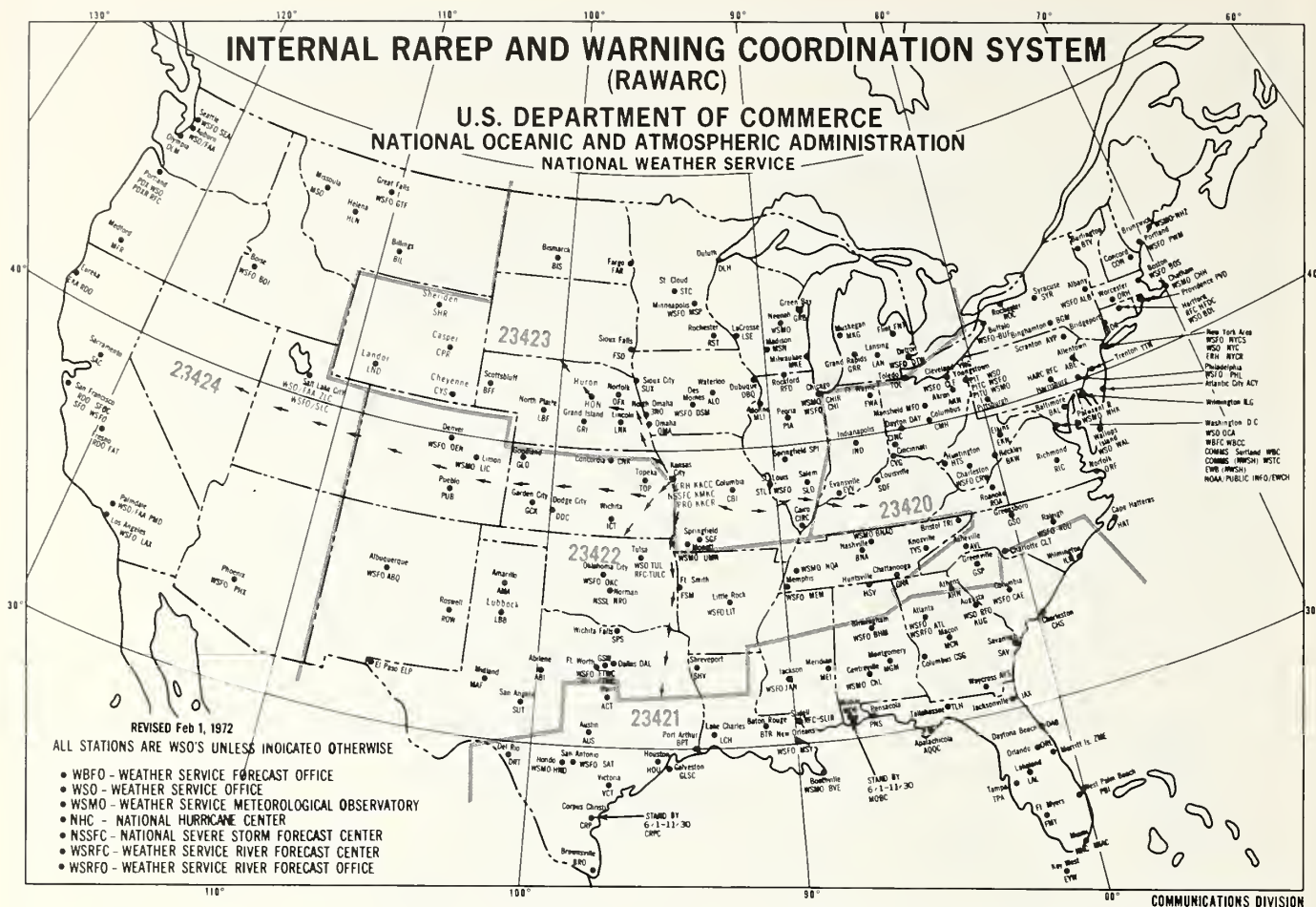


Figure 14. Radar Report and Warning Co-ordination (RAWARC) Teletypewriter Network.

- ☐ **Radio Broadcast Circuits:** 60-wpm distribution-only circuits for the transmission of data on the World Meteorological Organization and Caribbean Meteorological (CARMET) broadcast.
- ☐ **Government Medium-Speed Circuits:** 1,200-bps (bits per second) multipoint receive-only circuits for the distribution of Service A, C, and O data to very high volume FAA and NWS users whose needs cannot be satisfied by Area Circuits.
- ☐ **Nongovernment Medium-Speed Circuits:** 1,200-bps multipoint receive-only circuits for the distribution of Service A, C, and O data to very high volume airlines and other non-government users whose needs cannot be satisfied by Low-Speed Circuits.
- ☐ **High- and Medium-Speed Links:** 2,400-bps full-duplex computer-to-computer circuit for the exchange of Service A, C,

and O data between the WMSC and NMC.

1,200-bps full-duplex computer to-computer circuit for the exchange of Service A, C, and O data between the WMSC and the U.S. Air Force Air Weather Service.

1,200-bps full-duplex Notice to Airmen (NOTAM) circuit between the WMSC and National Flight Data Center.

The Service A and O Circuits are shown in figures 12 and 13.

Department of Commerce

Radar Report and Warning Coordination (RAWARC) Teletypewriter Network. The land-line teletypewriter network used to collect and to distribute radar reports and storm warning information is RAWARC. The Network is composed of five circuits which terminate at the Radar Analysis and Development Unit (RADU), the relay-and-monitoring stations for the Network in Kansas

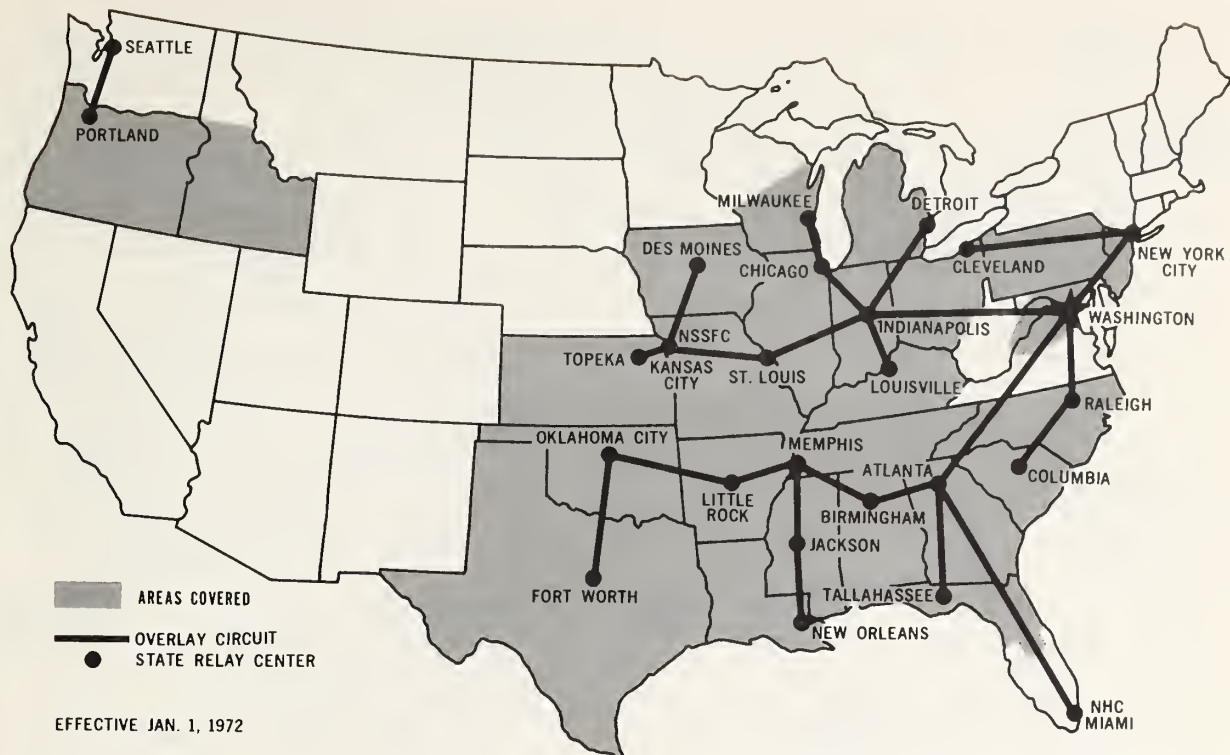


Figure 15. NOAA Weather Wire Service.

City. Traffic on RAWARC is basically unscheduled and is handled according to a priority system. The only regularly scheduled operation on RAWARC is an hourly collection of Radar Reports (SD) which are relayed by Kansas City as required. Figure 14 shows the RAWARC Teletypewriter Network.

NOAA Weather Wire Service (NWWS). This Service is a series of 60- and 75-wpm statewide and areawide circuits used to distribute consumer-oriented weather warnings, forecasts, and data from Weather Service Offices (WSO) to the mass news media for relay to the public and various specialized users. It incorporates the visual and audio capability to alert all users to critical incoming messages. The WSOs have direct entry on these circuits. The Service also includes three 100-wpm teletypewriter overlay-relay circuits which enable State Relay Centers to obtain and further distribute the required information from other States. The WSFOs furnish broad-scale information and the WSOs enter local information. This NWWS is expanding and will eventually service approximately 5,000 radio stations, 600 television stations, and 1,700 newspapers in 3,000 cities and towns in the Nation. The mass-media subscriber pays only for the use of a local line and equipment. Figure 15 shows those areas now covered by NWWS.

International circuits. The Department of Commerce operates five international circuits to exchange meteorological data between the United States and Canada, the U.S.S.R., Great Britain, Japan, and Brazil. These include a Washington-Toronto high-speed circuit; a Washington-Moscow circuit for exchange of satellite information; and three other circuits—Washington-Bracknell (England), Washington-Tokyo, and Washington-Brasilia—that are part of the World Weather Watch program. The Washington-Bracknell circuit is also used to exchange facsimile charts. Figure 16 depicts the international circuits operated by Commerce.

Radio circuits. Weather messages and observations prepared aboard ships at sea are transmitted by radio, primarily by means of international Morse code, to shore-based radio stations. These messages are relayed to the NMC. The Teletypewriter Exchange Service (TWX), international communications carrier facilities, and U.S. Coast Guard circuits are used for the relays. Observations are automatically separated geographically and consolidated into bulletins which are distributed on domestic and international meteorological communications facilities. More than 1,000 observations are processed daily. Figure 17 shows the location of the radio stations in the system.

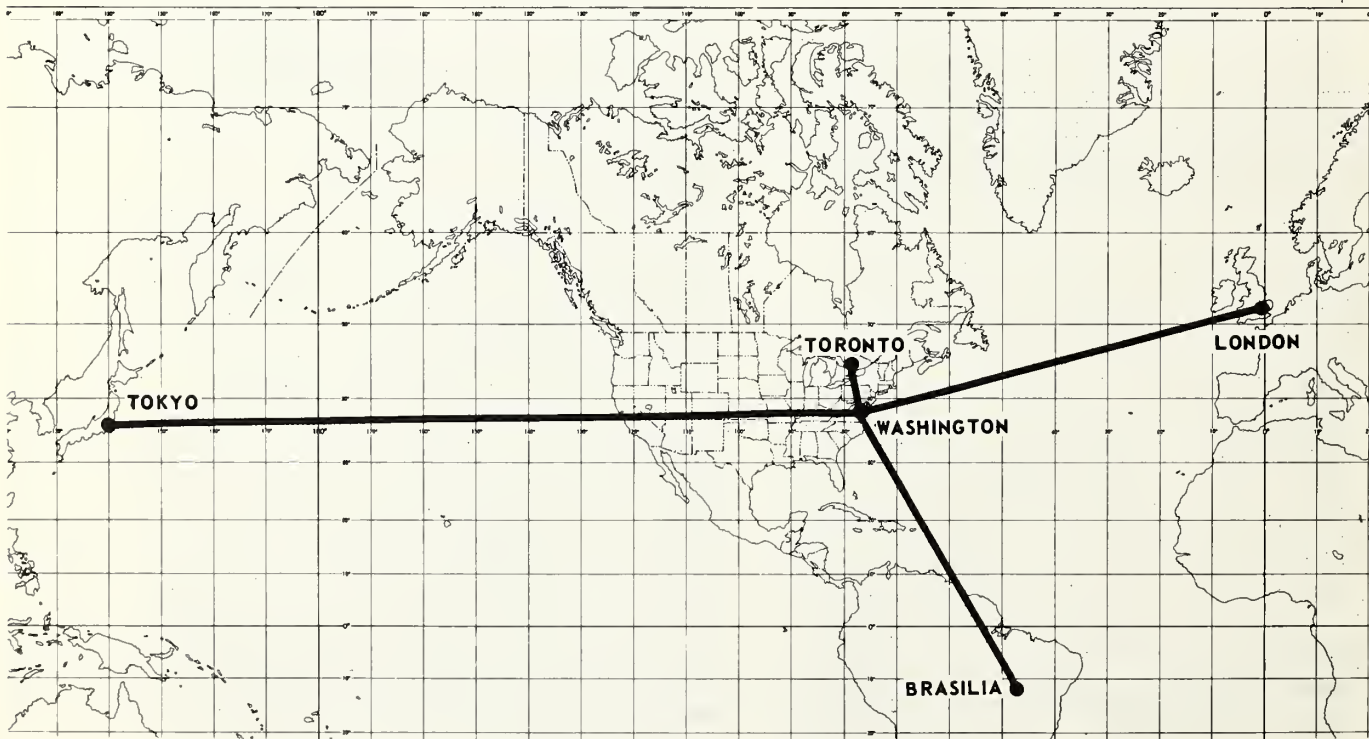
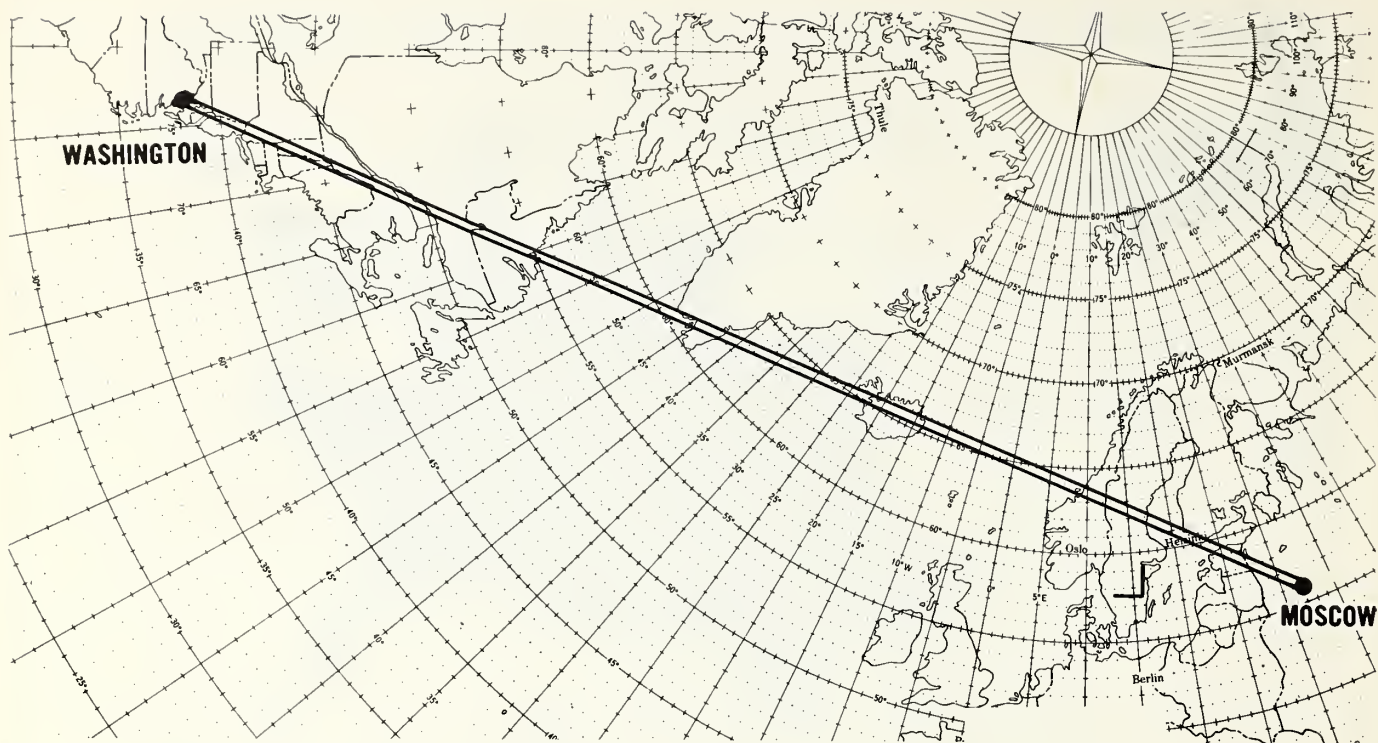


Figure 16. Commerce International Circuits.

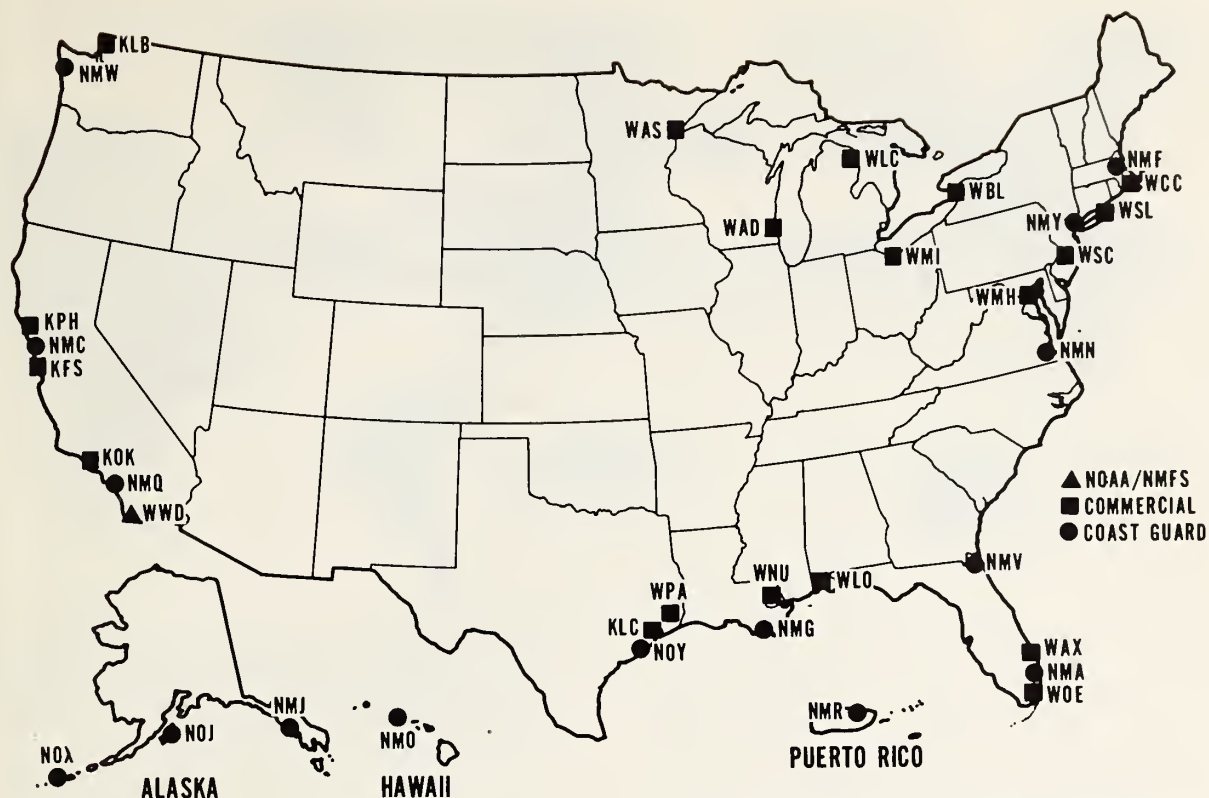


Figure 17. Radio stations which receive environmental information from ships.

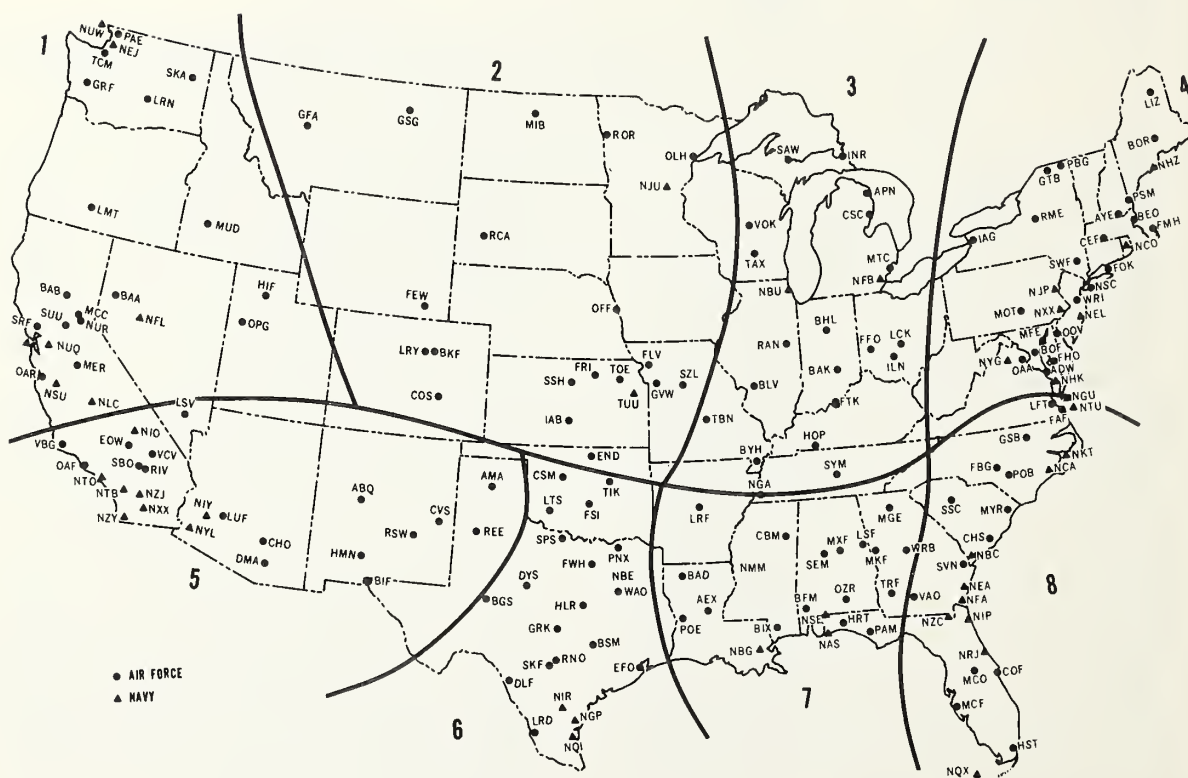
Department of Defense

Automated Weather Network (AWN). The AWN, the backbone of the military weather communications system, consists of four real-time communications switching computers linked together by high-speed data circuits. Low-speed feeder circuits collect and provide data to the overseas Automatic Digital Weather Switches (ADWS) located at Fuchu Air Station, Japan; Clark Air Base, the Philippines; and Croughton, England. These data are transmitted at 3,000 wpm to the Continental United States (CONUS) ADWS at Carswell AFB where the information is examined, sorted, edited, compiled into specific weather messages, and switched to military and civil customers. Besides low-speed distribution to Department of Defense weather units, data are transmitted by high-speed circuits to the Air Force Global Weather Central (AFGWC), Fleet Numerical Weather Central (FNWC), NMC, and the WMSC at Kansas City. All circuits are full-duplex, permitting a total exchange of data—both raw reports from field units to the military and civil processing centers and products from these centers to the field units. Figure

18 depicts the mainline circuitry for the AWN.

CONUS Meteorological (COMET) Teletypewriter System. The primary communications means for meeting requirements for collecting, editing, and disseminating environmental data at military stations in the United States is COMET, consisting of three teletypewriter networks—COMET I, COMET II, and COMET III. Each of these teletypewriter networks is subdivided into eight geographical areas as shown in figure 19. The COMET I Network consists of half-duplex 100-wpm loop circuits used for the collection and dissemination of airways data. The COMET II Network consists of full-duplex 100-wpm loop circuits used for the collection and dissemination of operational weather data. The COMET III Network consists of half-duplex 375-wpm broadcast circuits used for the dissemination of synoptic data. Polling for data collection on COMET I and COMET II is accomplished by means of an electric polling facility at Tinker AFB, Okla. Dissemination of data over COMET II and COMET III is controlled by the 1108 computer at the Carswell ADWS.

Naval Environmental Data Network (NEDN).



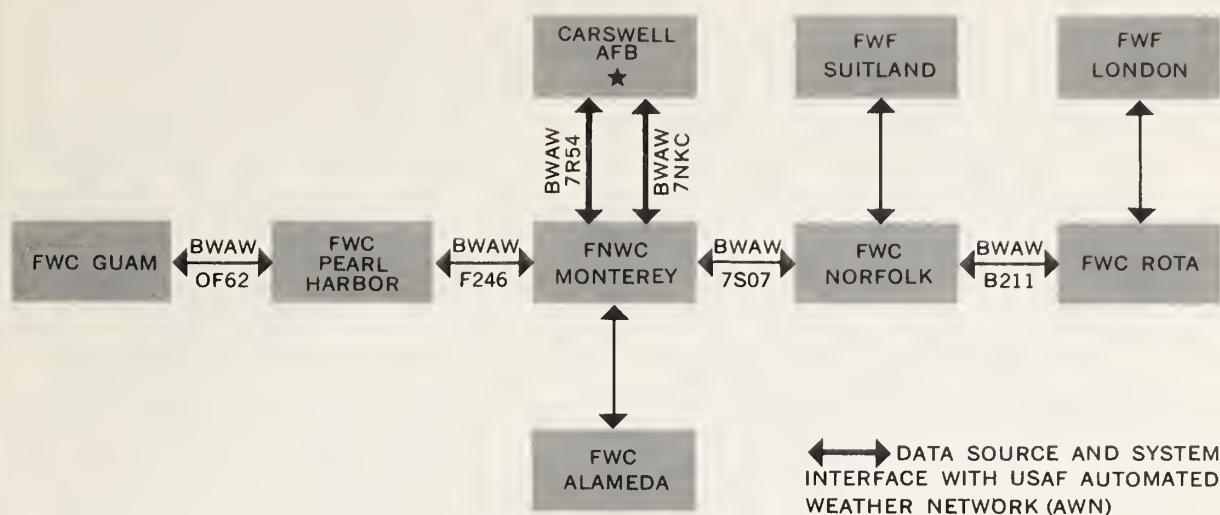


Figure 20. NEDN Mainline Circuitry.

The NEDN provides for the dissemination of meteorological and oceanographic computer products from FNWC at Monterey to specially equipped locations in the United States and overseas. The Network rapidly collects, processes, disseminates, and displays environmental data; it consists of on-line telecommunications equipment, automated display devices, digital computers, and associated circuitry. Figure 20 depicts the mainline circuitry for the NEDN.

Facsimile

Department of Commerce

National Facsimile (NAFAX) Network. The NAFAX is a long-line network generally used to distribute a comprehensive set of charts depicting analysis, prognosis, and selected observational data to civil and military weather service offices and to a variety of other users. Basically a graphics Network, the NAFAX serves approximately 250 WSOs, 320 military and other civil governmental offices, and nearly 350 nongovernmental users—more than 900 drops in all.

With the exception of the radar summary charts from RADU and the digitized mosaics from the National Environmental Satellite Service (NESS), all materials originate at NMC. The Network extends throughout the United States, with connections into Canada at Vancouver and Montreal. Charts are relayed to Alaska over military channels from West Sweetgrass, Mont. In Alaska, selected charts are put on the Intra-Alaska Facsimile Network circuit. Selected charts are also relayed to Honolulu.

Aviation Meteorological Facsimile (AMFAX) Network. The AMFAX is a long-line network de-

signed to distribute graphic analyses and prognoses to offices supporting international high-altitude aviation operations.

Graphic guidance materials in the form of manually prepared prognoses are entered on the circuit at Montreal, Honolulu, and by the NMC at Suitland. Additional entries are numerically prepared prognostic charts from NMC and digitized cloud mosaics from NESS. At selected times during the day, the Network is linked to the Intra-Alaska Facsimile Network, the Canadian Facsimile Network, and to international broadcast lines serving Honolulu, San Juan, and other countries. Figure 21 shows the AMFAX Network.

Forecast Office Facsimile (FOFAX) System. The FOFAX is a long-line network designed to distribute forecast guidance materials prepared by NMC and satellite products from NESS to the WSFOs. The System is also used to distribute NESS digitally prepared mosaics obtained from satellite pictures and automatic picture transmission data acquired by NESS Wallops Island, WSFO San Francisco, and U.S. Air Force Air Weather Service at Kunia, Hawaii. The System operates at variable speed (120 or 240 scans per minute) and has automatic selection of speed and mode. Figure 22 shows the FOFAX System.

Tropical Regional Analysis Facsimile Circuit (TROPRAN). The TROPRAN is a long-line network used to distribute tropical area analyses and prognoses. The Circuit carries NMC products for use by the National Hurricane Center and provides the NESS tropical-area satellite data for all users on the Circuit. Figure 23 shows the TROPRAN system.

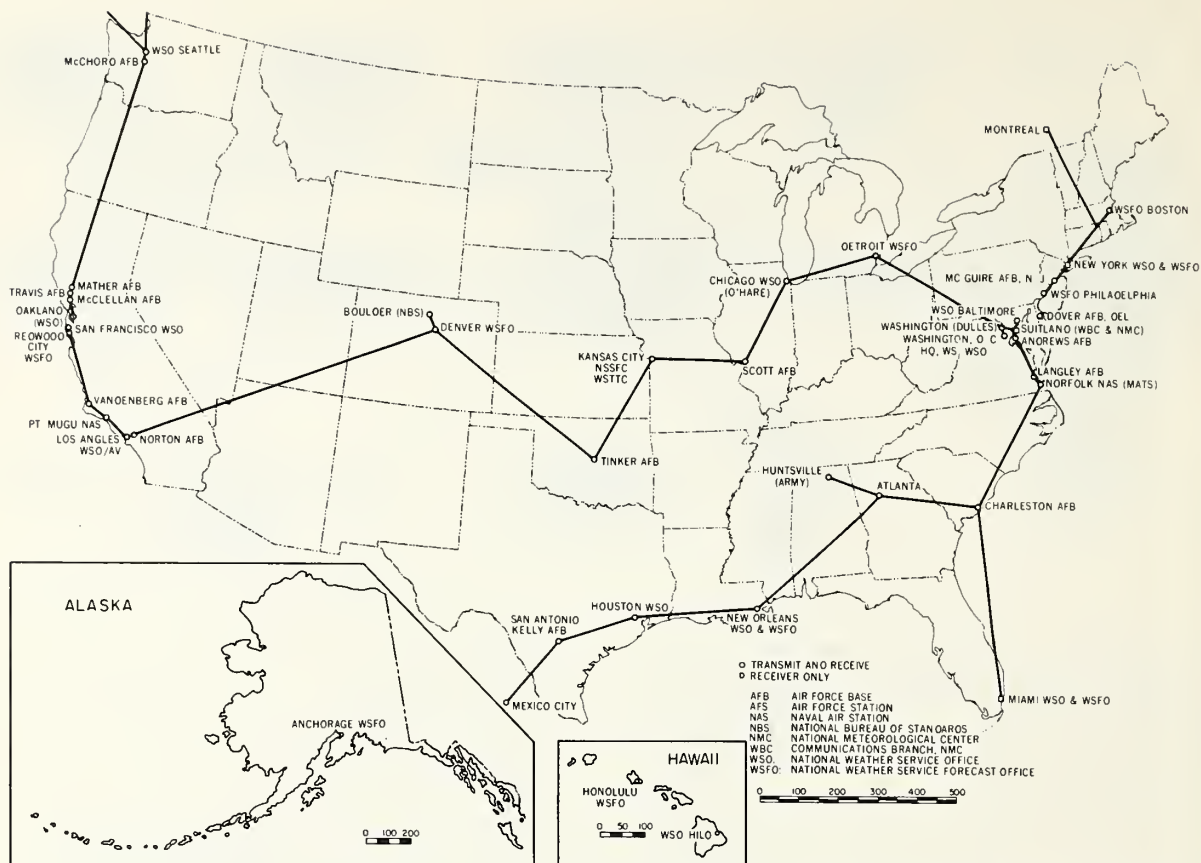


Figure 21. Aviation Meteorological Facsimile System (AMFAX).

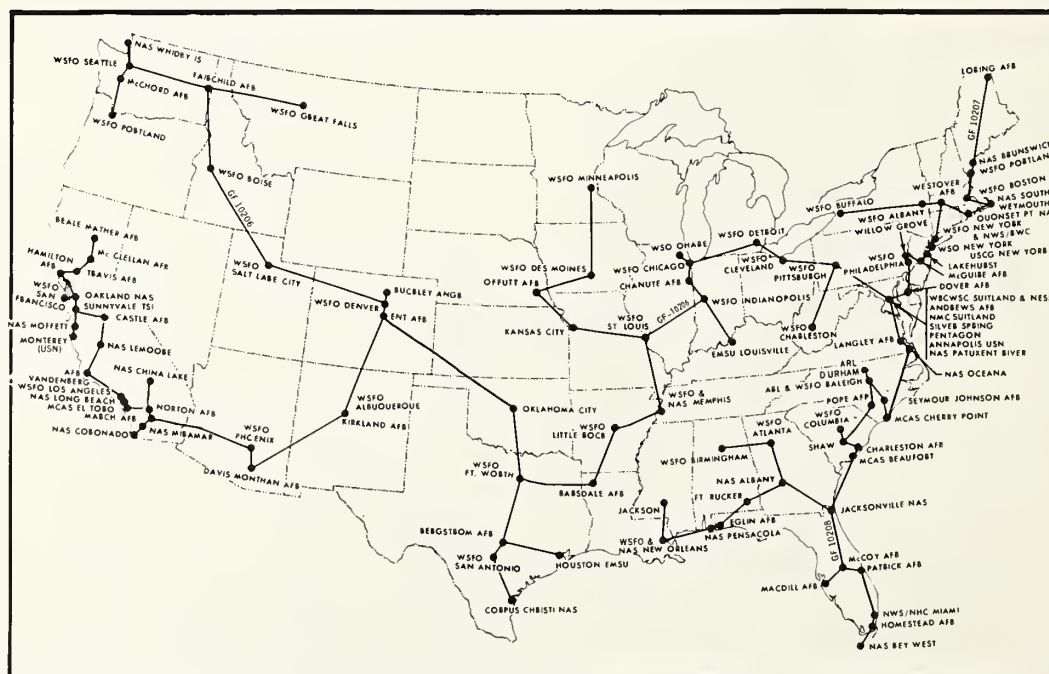


Figure 22. Forecast Office Facsimile Network (FOFAX).

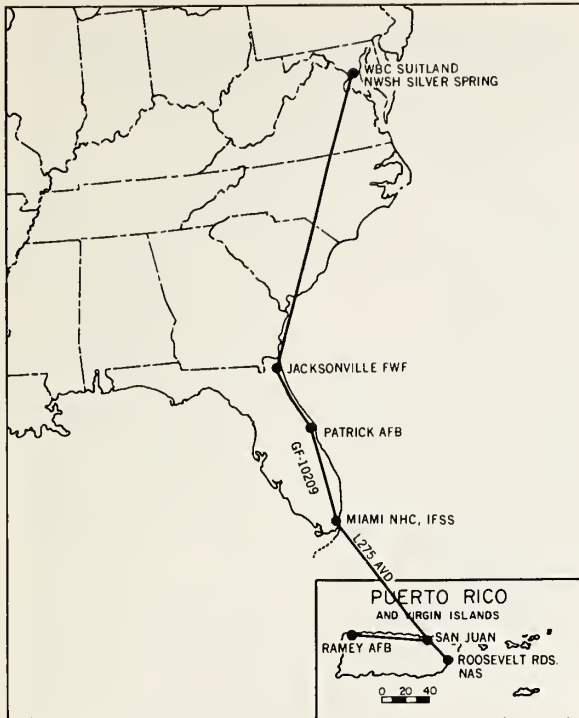


Figure 23. Tropical Regional Analysis Facsimile Network (TROPRAN).

Intra-Alaska Facsimile Network. This Network is a system of microwave, troposcatter, cable, and high-frequency radio facilities used to distribute graphic materials throughout Alaska. Besides the charts prepared by the WSFO Anchorage, selected charts are switched automatically into the Network from NAFAX and AMFAX. At the present time, the Intra-Alaska Facsimile Network serves 10 NWS, one Coast Guard, and eight Defense offices. The FAA and NOAA provide funds for that portion of the AMFAX circuit from the international border-crossing point at Blaine, Wash., to Smugglers Cove, Alaska. The NWS of NOAA provides approximately 90 percent of the funds for circuitry within Alaska and the Department of Defense supplies the remainder. Figure 24 shows the distribution of terminals on the Intra-Alaska Facsimile Network.

Department of Defense

Strategic Facsimile Network. The Strategic Facsimile Network is a landline and microwave net that extends to selected Defense users at approximately 80 locations in the United States. The AFGWC at Offutt AFB serves as the transmitting facility. The Strategic Facsimile Network supplements the facsimile systems of the Department of

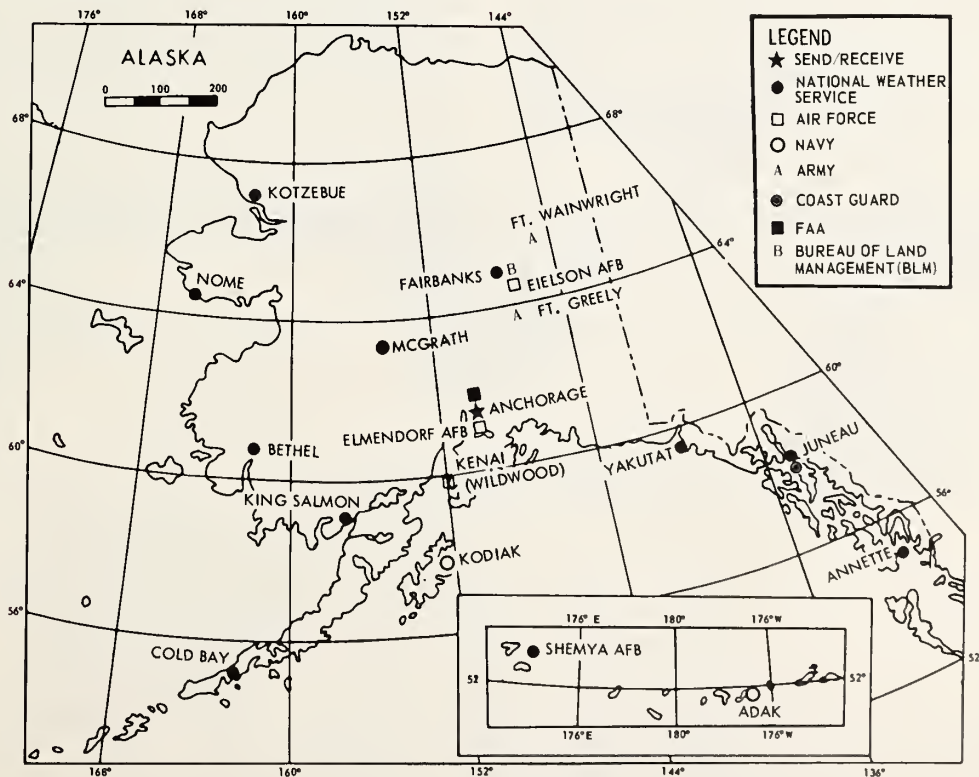


Figure 24. Intra-Alaska Facsimile Network.

Commerce by providing specialized graphic data oriented to military operations. It is used primarily to support the readiness of U.S. strategic weapons forces and secondarily to support airlift and tactical forces. The Network operates at 120 scans per minute and utilizes RJ-4-type facsimile recorders. Most products are computer-generated and introduced into the system through digital-to-analog converters. Figure 25 shows the Strategic Facsimile Network terminals.

Fleet Weather Broadcasts. The Naval Communications System supports the Naval Weather Service in its requirements for specialized operational communications. Meteorological traffic is handled in the same manner as other traffic; no centers or units are dedicated exclusively to meteorological communications. However, equipment needed to key transmitters and to receive data is installed directly in weather offices. Meteorological information is transmitted to operating forces of the U.S. Navy by means of radio (continuous wave, teletypewriter, and facsimile) broadcasts. These broadcasts are prepared by the Fleet Weather Centrals and Facilities and include observations, analyses, forecasts, and warnings. In preparing broadcasts, the Centrals and Facilities make use not only of their own specialized products and those from the FNWC, but they also make use—to the extent possible—of products from the Basic Meteorological Service and of data received from AWN. Type and location of Naval Weather Service activities keying radio broadcasts are shown on figure 26.

PROGRAM CHANGES FOR FY 1973

The communications function is subdivided into two categories—teletypewriter and high-speed systems, and facsimile. The following paragraphs

highlight program changes for the total communications function and the accompanying table shows the total cost, by agency, for various types of communications for FY 1972 and FY 1973.

An effective weather service is dependent upon an effective and complete communications system. Weather communications are planned, developed, and operated in consonance with the policies and standards promulgated by the National Communications System.

The major emphasis is to provide an improved flow of information to the public, particularly with regard to disaster warnings; this emphasis is reflected in Department of Commerce plans for improved communications. To provide for improvements, the Department is planning to extend or to complete the NWWS in New Hampshire, Vermont, Delaware, Maryland, District of Columbia, Virginia, West Virginia, Wyoming, Montana, and Colorado at \$395,000.

The Department of Defense plans a decrease in costs for FY 1973 of \$2,932,000 by closing facilities and reducing personnel as a result of automated weather editing and relay facilities.

The new and improved WMSC of FAA at Kansas City became operational in FY 1971. Funds of \$2,365,000 were programmed in FY 1972 for leased communications services for the operation of WMSC. The WMSC is expected to save 138 man-years over the old manual system at a reduction of \$1,569,000 for the partial year that it is in operation in FY 1972. For the full year of operation in FY 1973, 139 more man-years will be saved for a reduction of \$1,610,000. These reductions are offset some by increased costs of leased communications services of \$1,089,000 in FY 1972 and \$340,000 in FY 1973.

AGENCY OPERATIONAL COSTS, BY TYPE OF COMMUNICATIONS

	Teletypewriter and high-speed systems		Facsimile		Voice and continuous wave		Total	
	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73
AEC.....	7	7	7	7			14	14
Commerce.....	6,091	6,496	1,276	1,381			7,367	7,877
Defense:.....	(19,103)	(14,232)	(3,639)	(5,611)	(684)	(692)	(23,426)	(20,535)
Navy.....	2,509	2,536	609	615	684	692	3,802	3,843
Air Force.....	16,594	11,696	3,030	4,996			19,624	16,692
NASA.....	23	24	19	17			42	41
Transportation:.....	(16,140)	(15,236)	(599)	(631)			(16,739)	(15,867)
Coast Guard.....	63	66	64	67			127	133
FAA.....	16,077	15,170	535	564			16,612	15,867
Total.....	41,364	35,995	5,540	7,647	684	692	47,588	44,334

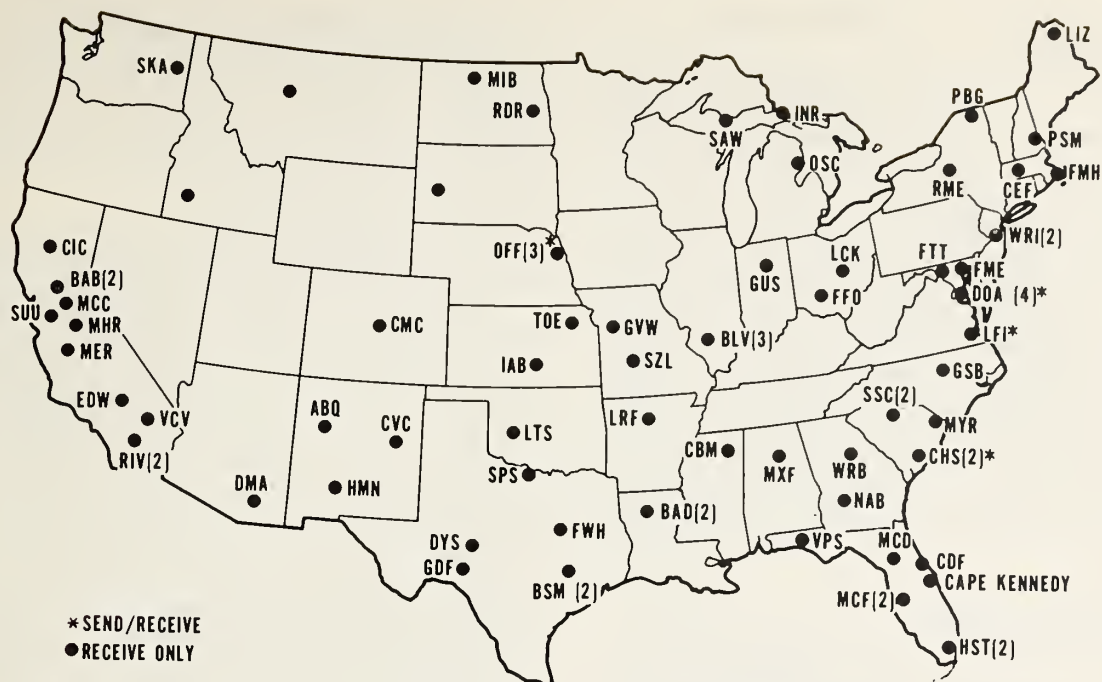


Figure 25. Strategic Facsimile Network.

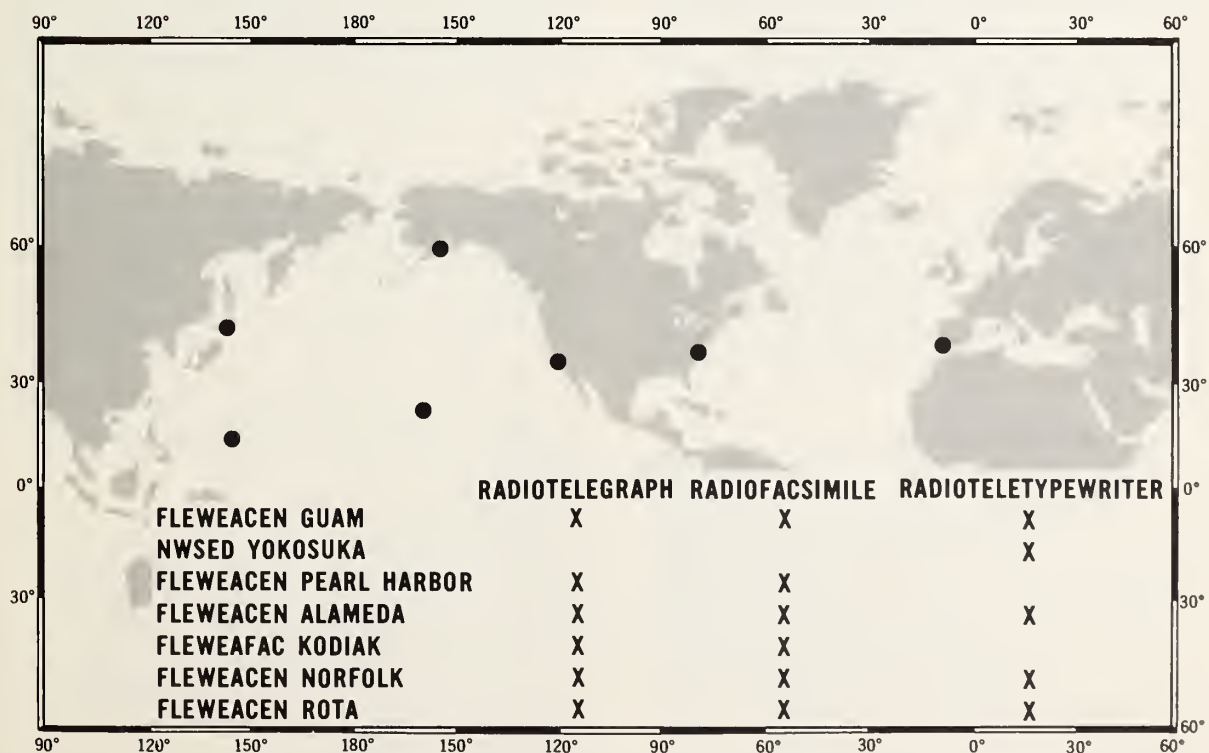


Figure 26. Fleet weather broadcasts.

DISSEMINATION TO USERS

DESCRIPTION

After weather observations have been collected and processed, the forecast and warning products must be presented in the proper form to the general public or user group for whom the service is designed. This final step in the production of meteorological services is accomplished in civil and military weather service offices. The products are conveyed to their consumers by personal briefings in the weather service offices; by voice communications devices such as telephones, telephone-answering recorders, and recorded broadcasts; by teletypewriters; by closed-circuit television; and by the Coastal Warning System. The Weather Service Offices (WSO) of the Department of Commerce provide up-to-date information to newspapers and to radio and television stations, using those news media outlets as the principal means to reach the general public.

Weather Service Offices

The Department of Commerce through NOAA has approximately 235 Weather Service Forecast Offices (WSFO) and WSOs that provide forecasts and warnings to the general public and to responsible State and local officials. Many of these WSFOs and WSOs have been supplemented with specially trained personnel who provide weather information for aviation, agriculture, fire-weather, and other specialized user groups. A few WSOs are operated solely to provide weather information for specialized users, as necessitated by technical or economic considerations.

The Department of Defense operates 428 weather service offices on land and aboard ship that furnish forecasting, briefing, climatological, and consultant services in support of military weapons systems, facilities, and installations. Defense mobile units provide weather support for maneuvers, exercises, and special military and contingency operations.

Flight Service Stations (FSS)

The FAA network of 333 FSSs provides weather information to aviation interests at civil airports. Many of these FSS facilities also furnish weather-briefing services by telephone to pilots at smaller airports that have no other weather information source. Some airports have both a FAA-FSS and a NOAA-WSO; the FSS personnel handle routine briefings while requests requiring a meteorologist are referred to the WSO.

Coastal Warning System

The Department of Commerce, U.S. Coast Guard, State and local governments, and private

interests cooperate in a Coastal Warning System to warn pleasure boatmen and other marine interests that lack radio-receiving equipment of impending weather conditions on coastal and inland waters; more than 490 flag or light displays are operated along the seacoasts, the shores of the Great Lakes, and on the inland waterways.

Voice, Teletypewriter, and Television

Voice communications systems have a major role in meteorological services. Weather information is disseminated to the general public through telephones, telephone-answering recorders, and very high frequency/frequency modulation (VHF/FM) continuous broadcasting. Use of recorders for distribution of weather information to the public, marine, and other specialized groups is on the increase; recorders allow a growing number of users to be served at minimum expense. For aviation users, the FAA operates radio broadcasts of recorded weather observations while the National Weather Service of NOAA provides forecasts and warnings. The Department of Commerce is increasing its use of continuous VHF/FM broadcasts to distribute forecasts and warnings to the general public as part of the Natural Disaster Warning System. The Coast Guard operates a number of radio stations to disseminate forecasts and warnings for coastal and offshore areas. The FM radio systems are also being used as emergency communications to link essential Commerce facilities with mass news media and public agencies in those areas where a high incidence of hurricanes and severe storms frequently disrupts normal communications. The Department of Defense operates 106 two-way radio stations in the United States for direct voice contacts between forecasters and airborne pilots.

Teletypewriter systems are used at many civil and military airfields to disseminate observations, forecasts, and warnings to air traffic controllers, aircraft operations offices, and other users. Closed-circuit television is used extensively by Defense to distribute weather information and to provide weather briefings for pilots and operational control personnel.

PROGRAM CHANGES FOR FY 1973

The dissemination to users function, as discussed, is divided into four main categories—weather service offices; FAA stations; Coastal Warning System; and voice, teletypewriter, and television. The following paragraphs highlight the program changes for the entire dissemination function, and the accompanying table lists the operational costs, by agency, for each of the categories.

Defense will improve its capability to provide weather support for tactical operations by the pur-

AGENCY OPERATIONAL COSTS, BY TYPE OF DISSEMINATION TO USERS

	Weather Service Offices		Flight Service Stations		Coastal Warning Service		Voice telecriber and television		Other		Totals	
	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73
AEC.....	95	98									95	98
Commerce.....	13,574	14,223					1,600	1,600			15,174	15,823
Defense:.....	(29,629)	(30,556)	(829)	(737)	(222)	(224)	(366)	(370)	(2,275)	(3,244)	(33,321)	(35,131)
Army.....									200	230	200	230
Navy.....	1,616	1,634	829	737	222	224	346	350	255	258	3,268	3,203
Air Force.....	28,013	28,922					20	20	1,820	2,756	29,853	31,698
NASA.....							22	18	45	58	67	76
Transportation:.....			(4,479)	(5,508)	(40)	(40)	(6,597)	(6,678)		(150)	(11,116)	(12,376)
Coast Guard.....					40	40	140	145		150	180	335
FAA.....			4,479	5,508			6,457	6,533			10,936	12,041
Total.....	43,298	44,877	5,308	6,245	262	264	8,585	8,666	2,320	3,452	59,773	63,504

chase of five tactical weather systems for the U.S. Air Force at \$2,900,000.

The Coast Guard, in response to a requirement for the dissemination of environmental information to the recreational boating public, is preparing a study to develop a passive system that will disseminate forecasts to boatmen at \$150,000.

The FAA anticipates a requirement for an additional 2.1 million pilot weather briefings and is planning an increase of \$1,029,000 to provide the expanded service.

GENERAL AGENCY SUPPORT

DESCRIPTION

General Agency support covers four activities—internal support, training, maintenance, and management above operating level—which agencies must sustain to operate effective meteorological service programs.

Internal Support

General mission-related activities in support of meteorological operations within an agency are necessary for providing service to users. These activities include the following types of programs:

- ☐ Engineering support to provide for planning, preparing technical specifications, surveying equipment sites for suitability, accepting and installing new equipment, and calibrating, maintaining, and repairing commissioned equipment systems.
- ☐ Scientific studies, services, and consultations to determine the feasibility of new programs and to increase the effectiveness of current programs.

- ☐ Quality control of products to assure the maintenance of standards for accuracy and productivity.
- ☐ Office quarters and employee housing at remote-area locations.

Training

Training in weather observations, communications, maintenance, and similar technician-level skills is accomplished at schools operated by Federal agencies; professional-level training is obtained by attendance at accredited colleges and universities. Training costs include instructor and student pay, equipment, travel, books, and tuition.

The major portion of the Federal training effort is performed by Department of Defense agencies to meet their military requirements. Technician-level training is conducted at Defense schools. The U.S. Air Force and U.S. Army use colleges and universities for both basic and advanced training of their professional-level personnel. The U.S. Navy, however, provides professional-level education leading to baccalaureate and advanced degrees at its Postgraduate School in Monterey and uses civilian colleges or universities primarily for special or doctoral degree work. Some personnel trained under these Defense programs are employed by civilian meteorological agencies after these individuals have left the military service. This action significantly reduces the need for meteorological training programs in other Federal agencies.

The Department of Commerce operates the NOAA National Weather Service (NWS) Technical Training Center at Kansas City for the training of meteorological technicians and electronics and facilities maintenance technicians. A refresher

AGENCY OPERATIONAL COSTS, BY TYPE OF GENERAL AGENCY SUPPORT

	Internal support		Training		Maintenance		Management above operating level		Total	
	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73
AEC.....	380	389	136	139	14	14	54	55	584	597
Commerce.....	6,107	6,472	934	921	11,842	14,657	2,499	2,684	21,382	24,734
Defense:.....	(5,978)	(4,204)	(16,439)	(19,823)	(13,055)	(12,144)	(11,104)	(10,435)	(46,576)	(46,606)
Army.....			1,399	1,134			78		1,477	1,134
Navy.....	2,535	2,562	6,337	6,405	3,352	2,882	1,267	1,281	13,491	13,130
Air Force.....	3,443	1,642	8,703	12,284	9,703	9,262	9,759	9,154	31,608	32,342
EPA.....	515	700							515	700
NASA.....	43	76	16		101	412	128	122	288	610
Transportation:.....	(2,112)	(2,123)	(1,884)	(1,524)	(3,685)	(3,883)	(2,558)	(2,629)	(10,239)	(10,159)
Coast Guard.....			122	122			43	43	165	165
FAA.....	2,112	2,123	1,762	1,402	3,685	3,883	2,515	2,586	10,074	9,994
Total.....	15,135	13,964	19,409	22,407	28,697	31,110	16,343	15,925	79,584	83,406

course at the professional level for meteorologists is given at NWS Headquarters in Silver Spring, Md. Other professional-level training is obtained through colleges and universities or in programs operated by other Federal agencies. The U.S. Coast Guard operates a Marine Science Technician (MST) Class-A School for basic training in its MST rating. Approximately 40 percent of this curriculum is devoted to meteorology, replacing the basic training which had been previously obtained through the Navy's Aerographers Mate schools. The FAA Academy at Oklahoma City provides that agency's personnel with the meteorological training required for air traffic control and the technician training required for weather observations and for communications equipment maintenance. The EPA conducts air pollution meteorology training programs for professionals in air pollution control activities at the Federal, State, and local levels.

Some economies in training activities are being realized through use of one agency's training program by another. This arrangement saves duplicating facilities and staffs. Also, Commerce is effecting additional economies through the use of home-study courses, utilizing both commercial correspondence and in-house-developed programs, to supplement formal residence courses.

Maintenance

Maintenance is performed at central overhaul facilities and at regional and local shops. The majority of the maintenance effort is accomplished at the local level where emphasis is placed on preven-

tive maintenance and on swift emergency actions to restore vital facilities to operation.

The Departments of Defense and Commerce operate central overhaul facilities where major repair or rebuilding operations are completed on entire items or on major components of equipment. Regional maintenance facilities are supported by Defense to furnish technical assistance to local maintenance shops and to perform those preventive and corrective maintenance actions which are beyond the capability of the local shops.

Management Above Operating Level

Management, supervision, administration, and logistic support are considered an integral part of units at the operating level; however, a certain amount of executive management, administration, and logistic support must come from higher echelons. In general, the management above operating level of units is confined to civil agency headquarters, to civil regional offices, and to similar headquarters in the military agencies.

PROGRAM CHANGES FOR FY 1973

The following paragraphs highlight the program changes for the general agency support function, and the accompanying table lists the operational costs, by agency, for each of the four categories previously discussed.

The Department of Commerce is planning a number of activities in FY 1973, each of which is designed to maintain or to improve services. Commerce must relocate four radar and eight upper air facilities; to accommodate the moves, an increase of \$1,005,000 for new construction is planned. To

avoid excessive maintenance costs in subsequent years, Commerce is securing additional staff to maintain its physical plant and facilities at \$525,000. In a related program, Commerce will begin the systematic replacement of overaged and outmoded equipment, such as local-use radars and fixed-beam ceilometers, at \$500,000. To provide the staff and the spare parts to maintain newly installed electronic equipment, Commerce will expend an additional \$709,000. The facilities at Kodiak, Alaska, that are in the process of being transferred from the Department of Defense to Commerce need rehabilitation, for which Commerce is budgeting an additional \$220,000.

Defense had planned in FY 1972 for significant building programs at both the Air Force Global Weather Central, \$610,000, and the Fleet Numerical Weather Central, \$1,241,000. The Air Force

program has been deleted; the Navy program, unfunded in FY 1972, is being reprogrammed for FY 1973 in the same amount. To assure continuous operation at the AFGWC, the Air Force plans to provide auxiliary "no-break" power at \$588,000. In the training function, Air Force expects a cyclical peak in training of maintenance personnel, increased costs for training courses, and projected increases in training of new weather observers to cost an additional \$3,581,000. In the maintenance function, Defense plans to increase the spare parts and supplies at Strategic Aerospace Command bases to reduce down time of observing equipment at \$952,000.

To provide an adequate maintenance program for the additional equipment being installed, RBCs and RVRs, the FAA programmed an additional \$568,000 in FY 1972 and \$173,000 more in FY 1973.

Weather Satellites

INTRODUCTION

The satellite continues to play an increasingly important observational role, along with the more conventional techniques of measuring the atmosphere such as aircraft weather reconnaissance, radar, and surface-based upper air sounding systems. The satellite provides the meteorological information required to produce more accurate weather analyses and forecasts, more complete and timely storm warnings, and better oceanographic forecasts. This section of the Plan describes the meteorological satellite system now in operation, the applications being made to meteorological service, and the operational and supporting research plans for service improvement. Detailed information on these aspects of the meteorological satellite system will be found in the *Federal Plan for Meteorological Data From Satellites*.

NATIONAL OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM

The Department of Commerce, through the National Environmental Satellite Service (NESS) of NOAA, is the executive agency for a national operational environmental satellite system. In that capacity, the Department is charged with operating and improving the system to meet the coordinated requirements of all Federal agencies.

The system is based on space technology developed by NASA which also procures and launches spacecraft according to Commerce specifications and uses Commerce funds on a reimbursable basis. The meteorological program objectives of the operational system are:

- ☐ A system for viewing the atmosphere regularly and reliably on a global basis, both day and night, with direct readout to local ground stations within radio range of the satellite.
- ☐ A system for continuous viewing of weather features and for collecting and relaying meteorological data from remote platforms such

as buoys, ships, automatic stations, aircraft, and balloons.

- ☐ A system for sounding the atmosphere regularly and reliably on a global basis and for providing quantitative inputs into numerical weather prediction.
- ☐ The application of meteorological satellite data for improving weather services.

The operational system consists of flight programs directed to the above objectives, Command and Data Acquisition (CDA) stations and a Satellite Operations Control Center through which satellites are controlled and stored data are acquired, facilities for the processing and analyzing of satellite products, and laboratories for developing applications of satellite data and satellite sensor experiments. Within the conterminous United States, some direct readout and processed products are distributed to users over facsimile networks.

FLIGHT PROGRAMS

The Improved TIROS (Television Infrared Observation Satellite) Operational Satellite (ITOS) has now replaced the original TIROS Operational Satellite (TOS) which provided operational daytime global-viewing and direct readout to local ground stations without interruption since February 1966. These satellites are flown in circular, sun-synchronous orbits at an altitude of about 790 nautical miles. The current ITOS spacecraft continue the services previously provided with the addition of nighttime-viewing to satisfy the first major program objective completely. The ITOS also carries a Solar Proton Monitor as a secondary sensor and has a capability to accommodate sensor changes planned for operational polar-orbiting weather satellites through 1975. The ITOS system is shown in figure 27.

The prototype ITOS satellite, funded by NASA and designated as TIROS M, was launched on January 23, 1970, as ITOS 1. NOAA 1—the first operational ITOS spacecraft—was launched on December 11, 1970, to provide full redundancy in orbit and to assure continuity of ITOS functions.

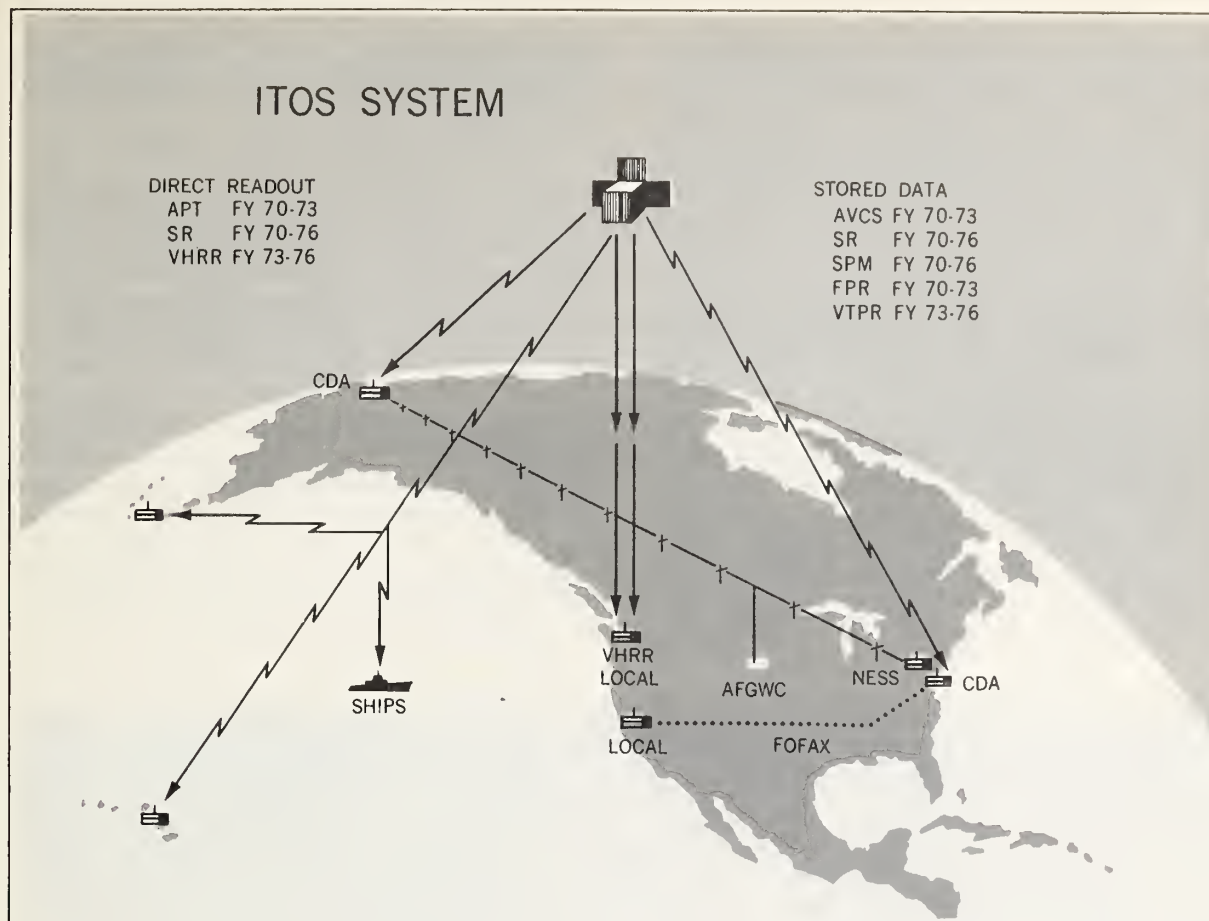


Figure 27. Schematic of ITOS System.

However, both the prototype, ITOS 1, and the first operational spacecraft, NOAA 1, failed early in FY 1972 because of malfunctions associated with the stabilization and control assemblies. The replacement spacecraft, ITOS B, launched on October 21, 1971, failed to orbit, the result of problems in the second stage of the launch vehicle. The ITOS C is planned for launch in the third quarter of FY 1972 and will restore the day-night ITOS service.

In the interval following the loss of ITOS 1 and NOAA 1, a spacecraft of the older TOS series, the Environmental Survey Satellite (ESSA) 8, continues to furnish automatic picture transmission (APT) service while the ESSA 9 spacecraft provides advanced vidicon camera system (AVCS) daytime service.

NOAA has joined with NASA to continue real-time acquisition and use of data from research satellites—Applications Technology Satellites (ATS) 1 and 3 in geostationary orbits over the eastern Pacific and western Atlantic Oceans and Nimbus 4 in sun-synchronous polar orbit.

The tables at the end of this section summarize

the first decade of meteorological satellite flights and also list flights launched or planned, with an indication of the sensors and functions provided, for the period 1970 through 1974.

DATA APPLICATIONS

Global stored data are received at CDA stations, processed into products required by users, and distributed for use at the three primary analysis and forecasting centers—the NOAA National Meteorological Center (NMC), the Air Force Global Weather Central (AFGWC), and the Navy Fleet Numerical Weather Central. The processed products are also distributed to other NOAA and Defense units by means of facsimile landlines. The direct readout system supplies regional observations in real-time for detailed analysis and for use by other forecast centers and services throughout the world.

Techniques to derive quantitative information from satellite data continue to improve. These quantitative data are needed on a worldwide basis for numerical weather forecasting. Tech-

niques now in routine use include estimates of windspeed and wind direction, maximum windspeeds within hurricanes, moisture content, and circulation patterns deduced from cloud photographs. Geopotential heights and vertical-temperature profiles are routinely prepared from Satellite Infrared Spectrometer (SIRS) data obtained from Nimbus 4.

Time-sequence movie loops, prepared from the geostationary ATS 1 and 3 photographs, have been integrated into the NMC, the National Hurricane Center (NHC), and the National Severe Storms Forecast Center (NSSF) operations and development programs based on the concept of near-continuous coverage from the geostationary satellite.

The Satellite Input to Numerical Analysis and Prediction (SINAP) technique is in routine use for analysis of the northeastern North Pacific Ocean. The SINAP separates the 12-hour 500-millibar forecast height field into short- and long-wavelength components to derive quantitative

geopotential heights of constant-pressure surfaces. Satellite photographs are used to modify the short-wavelength components before determining the forecast field.

Methods to determine sea-ice distribution and sea-surface temperature have been improved; techniques to correct scanning radiometer data for atmospheric radiation and for filtering system noise have been developed, permitting more effective mapping of global sea-surface temperature. Methods have been developed to enhance display of thermal patterns so that eddies and meanders of currents are depicted. Methods of monitoring polar-ice packs have been improved by displaying composite minimum-brightness charts in five shades of gray that correspond to categories of ice concentration and condition. Procedures to enhance the contrast of water, ice, and land boundaries have been improved by assigning limited numbers of gray tones to temperature intervals that correspond to various ice condition and concentration, open

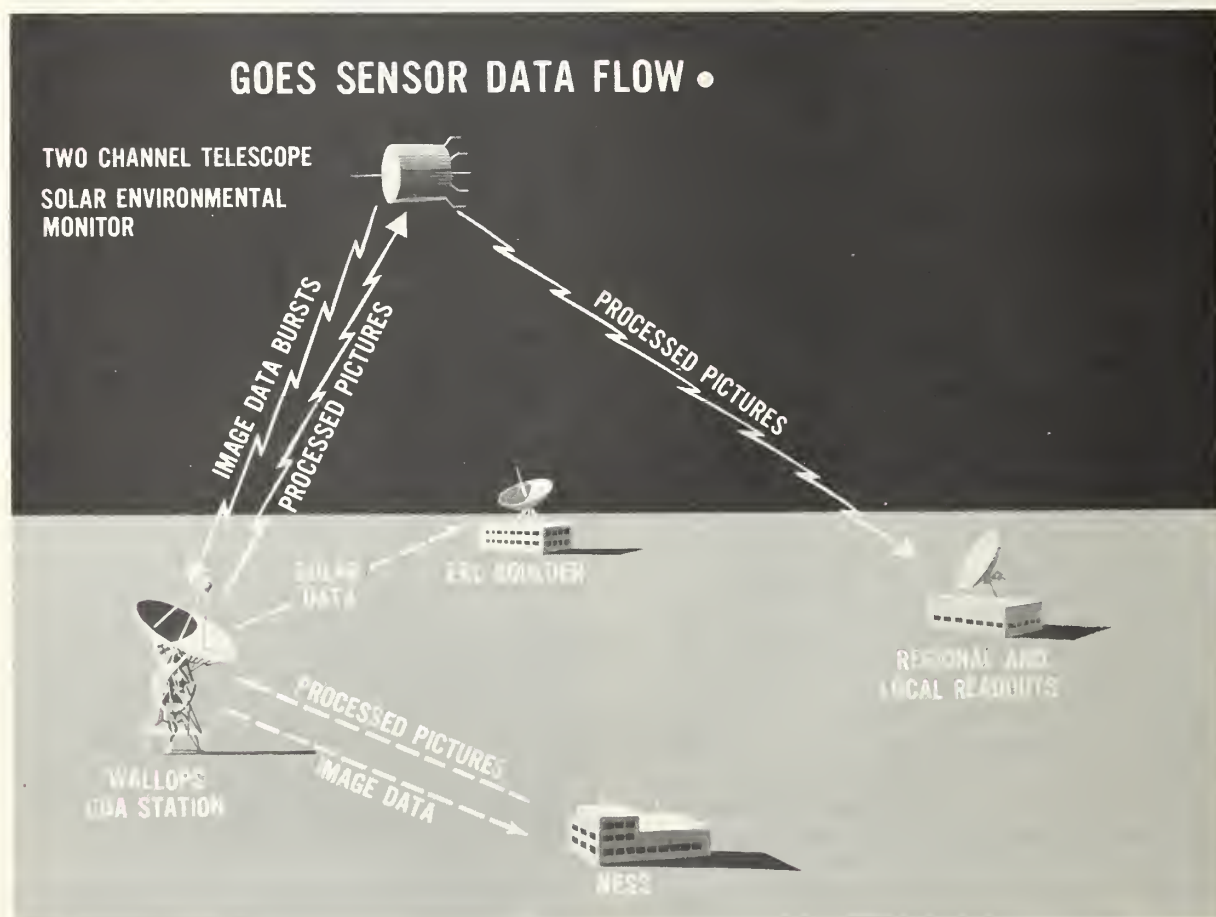


Figure 28. Schematic of GOES sensor data flow.

water, and land. Techniques have been developed for determining the thaw conditions of snowfields, using comparative analysis of satellite observations in the visible and near-infrared spectra.

OPERATIONAL PLAN

SPACECRAFT AND LAUNCHING

The ITOS system will be maintained with launches as needed, projected at about 1-year intervals. ITOS D is scheduled to be launched in the first quarter of FY 1973; ITOS E is available as a backup.

Future satellites of this series, beginning with ITOS D, will include a capability for obtaining vertical temperature and moisture profiles of the atmosphere. Addition of the Vertical Temperature Profile Radiometer (VTPR) system will provide the first operational system for sounding the atmosphere twice daily on a global basis, a major objective of the national operational environmental sat-

ellite system. The Very High Resolution Radiometer (VHRR) system will provide high resolution (0.5 n. mi. under satellite track). The VHRR will operate mainly as a unique local readout subsystem to specially equipped locations, with limited high-resolution storage capacity to obtain data from selected remote areas. The vidicon camera systems currently in use will be deleted, with their day-time-viewing function being performed by the combined day- and night-viewing and temperature-sensing capabilities of the Scanning Radiometer (SR). The primary sensor complement—SR, VHRR, and VTPR—is expected to continue on the polar-orbiting satellites into FY 1976. The APT service will continue with the signal provided by the SR; day and night service will be available from the SR which observes in both the visible and infrared spectra. Present APT ground stations *will not become obsolete*; however, to receive SR data, a conventional APT ground-station recorder must be modified. The details of the modification are a

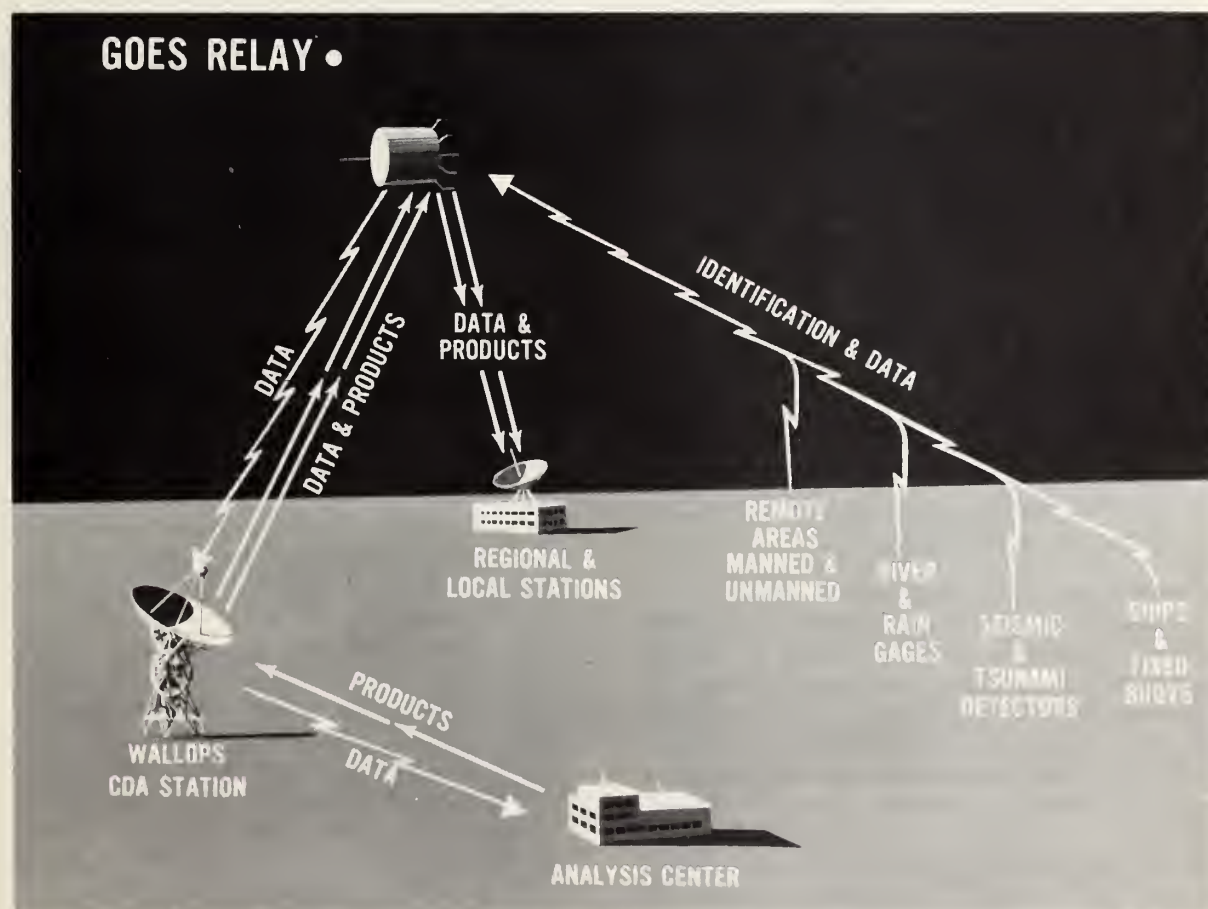


Figure 29. Schematic of GOES relay system.

function of the manufacturer and type of recorder.

The initial operational capability for near-continuous day and night cloud-viewing and data collection-and-relay will be established with the launch of the Synchronous Meteorological Satellite (SMS), the SMS A—the NASA-funded prototype for the Geostationary Operational Environmental Satellite (GOES). NOAA is funding the follow-on operational GOES spacecraft to maintain the GOES system. The SMS/GOES will carry the Visual and Infrared Spin-Scan Radiometer (VISSR) system, providing nearly continuous observation of cloud-cover day and night and measurements of cloud-top and surface temperatures. Wind information will be derived from cloud motions. A data collection-and-relay capability will be included for acquisition of raw data from surface platforms and for relay of processed data from analysis centers to remote-receiver stations. A Space Environment Monitor will also be carried. The GOES sensor data flow is shown in figure 28. The GOES relay flow is shown in figure 29.

The first operational prototype, the SMS A, is scheduled for launch about mid-FY 1973 and will be located over the Equator at about longitude 100°W. This location will provide near-continuous high-resolution surveillance of an area 6,500 nautical miles in diameter beneath the spacecraft and data relay over an area of about 9,500 nautical miles in diameter. With the launch of SMS B and the subsequent replacement GOES satellites in later years, it is planned to maintain two satellites in geostationary orbit, providing near-continuous viewing and data collection-and-relay over a major part of the Western Hemisphere between latitudes 55°N. and 55°S.

NOAA funds in FY 1973 are for accrued costs of the construction of the ITOS E through G spacecraft and of the GOES A; for initiation of a new spacecraft H, the launch vehicle for GOES A; and for launch services for ITOS E.

COMMAND AND DATA ACQUISITION (CDA)

Increased funding is requested for equipment and staff needed at the CDA stations to maintain previously approved programs and to proceed with planned program improvements. The Commerce increase for CDA of \$2,603,000 is for equipment needed for providing reliable service with a one-satellite GOES system, staff required for safe operation and maintenance of the one-satellite GOES system, additional equipment needed for operation of a two-satellite GOES system beginning the third quarter FY 1974, and procurement initiated for unique ground equipment for TIROS N.

Defense is upgrading a number of APT ground stations to receive weather facsimile (WEFAX)-type transmissions through GOES and to secure for more effective use of the ITOS APT service. The detailed description of APT system operations is contained in the *Federal Plan for Meteorological Data from Satellites*.

More expensive and complex ground equipment in development will be required to receive the VHRR data in full resolution from ITOS spacecraft and the VISSR data from GOES spacecraft. Direct VISSR transmission from the SMS/GOES will be receivable only at major CDA stations such as at Wallops Island. This wide-band transmission will be processed at the Wallops CDA Station to reduce transmission bandwidth and will be relayed in real-time back through the GOES spacecraft to suitably equipped remote ground-receiving stations.

DATA PROCESSING

The NESS and AFGWC receive all stored data from the TOS and ITOS spacecraft for computer processing. The NESS uses the NOAA central computers, smaller computers, and manual techniques to convert observational data into forms suitable for immediate operational use in analysis and forecasting routines and for subsequent research and climatological uses.

In the Department of Commerce, FY 1973 increases are required to handle new data—analysis, processing, dissemination, and archiving—from the GOES operational prototype and from the advanced ITOS sensors, the VHRR and VTPR. Commerce is budgeting an increase of \$3,492,000 in FY 1973 for this purpose which will include additional computer facilities, a Data Utilization Station for Honolulu, computer time for the Earth Resources Technology Satellite Data Center, and the NOAA Data Assimilation Initiative.

Staff will be added to the central analysis and processing facility of NESS. These additions will round out the currently estimated staff required to undertake major new tasks—derive atmospheric soundings and winds for use in numerical weather prediction programs and prepare special service-oriented products from VHRR data such as high-resolution sea-surface temperature analyses for selected areas, sea and lake ice distribution charts, and detailed snow cover charts for use in marine, hydrology, and flood-warning service programs.

Staff will be added also to the Washington Weather Service Forecast Office (WSFO), and the NHC to acquire and use data from GOES in environmental advisory and warning service programs.

A pilot project to use and evaluate VHRR data

AGENCY OPERATIONAL WEATHER SATELLITE PROGRAM COSTS, BY FUNCTION

	Spacecraft and launching		Command and data acquisition		Data processing		Technical management and support		Total	
	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73
Commerce.....	13,853	13,994	6,567	9,170	9,872	13,364	2,828	3,352	33,120	39,880
Defense:.....			(1,369)	(1,416)	(562)	(614)			(1,931)	(2,030)
Navy.....			1,157	1,212					1,157	1,212
Air Force.....			212	204	562	614			774	818
Total.....	13,853	13,994	7,936	10,586	10,434	13,978	2,828	3,352	35,051	41,910

in a variety of environmental service programs in Alaska will be initiated at the Gilmore, Alaska, CDA.

TECHNICAL MANAGEMENT AND ENGINEERING

Technical management and engineering support for the operational weather program are provided by NASA on a reimbursable basis and by NOAA. With the evolution of the GOES program, reimbursement to NASA will increase by \$75,000 to cover services provided through the SMS/GOES Project Office. The NOAA increase will be \$524,000, with \$135,000 of this amount programmed for advanced data-collection platform engineering.

SUPPORTING RESEARCH

Meteorological research conducted by NASA and the Departments of Commerce and Defense provides the technology and data utilization techniques necessary to meet the major long-term objectives set by these Federal agencies in their planning for a coordinated meteorological satellite program. For FY 1973, planned meteorological satellite research and development programs reflect an increase of \$18,968,000 over the FY 1972 program.

Developments necessary for the global-viewing, the first major program objective, were largely achieved with the TIROS M and ITOS spacecraft. Efforts continue toward improved resolution, location, and display. Attention is also being given to the development of methods for measuring additional environmental properties, to the solution of data and product distribution problems, and to the improvement of ground stations.

The second major program objective includes both continuous viewing and the collection and re-

laying of meteorological data from instrumented platforms such as buoys, ships, automatic stations, aircraft, and balloons. NASA conducts experiments in support of this objective with its Nimbus and ATS series. In addition, NASA is funding the SMS prototypes for the GOES operational spacecraft.

The third major program objective for sounding the atmosphere regularly and reliably on a global basis and for providing quantitative inputs into numerical weather prediction is also being supported by NASA in experiments conducted on the Nimbus series. The TIROS N flight program to be initiated in FY 1973 is the forerunner of the advanced operational spacecraft to provide this capability.

Research and development for precise quantitative atmospheric sounding, the third major program objective, are emphasized in the Nimbus program of NASA and in the program of NOAA to develop sensing techniques. After a year in orbit and successfully completing all of its mission objectives, Nimbus 4 suffered a failure of the rate measurement package which degraded the yaw stability. However, useful data continue to be obtained from all but two instruments—the Filter Wedge Spectrometer (FWS) and the Temperature and Humidity Infrared Radiometer (THIR) which have stopped operating.

Commerce and Defense conduct a wide variety of studies on the applications of meteorological satellite data to improve services—the fourth major program objective. Major efforts will be directed to the development of new methods for using satellite data in environmental analysis and forecasting. The radiative and optical properties of atmospheric constituents are being studied to aid with the design of satellite-borne sensors and with the interpretation of data from these sensors. Special attention is

given to the interpretation and validation of new data acquired by operational and research satellites and to the application of these data as inputs to numerical analysis and forecasting.

Meteorological satellite research efforts are described in detail in the *Federal Plan for Meteorological Data from Satellites*. These efforts are re-

flected in the description of the polar-orbiting satellites—Nimbus E and F and TIROS N—the geosynchronous meteorological satellite, and in the description of applications developments.

The accompanying table lists the agency supporting research costs, by function, for the weather satellite program.

AGENCY SUPPORTING RESEARCH WEATHER SATELLITE PROGRAM COSTS, BY FUNCTION

	Satellite flight projects		Satellite instruments and experiments		Spacecraft tech. and associated ground equipment		Satellite data analysis and applications		Total	
	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73	FY 72	FY 73
Commerce.....			1,117	1,142			1,264	1,289	2,381	2,431
Defense:.....							(497)	(685)	(497)	(685)
Air Force.....							115	115	115	115
Army.....							182	370	182	370
Navy.....							200	200	200	200
NASA.....	34,625	47,000	885	1,155	9,845	15,505	700	1,125	46,055	64,785
Total.....	34,625	47,000	2,002	2,297	9,845	15,505	2,461	3,099	48,933	67,901

Weather Satellites 1960-1969

Satellite	Purpose	Launch date	Operations ceased date	Satellite	Purpose	Launch date	Operations ceased date
TIROS I	Research	4/ 1/60	6/15/60	NIMBUS 2	Research	5/15/66	11/15/66
TIROS II	Research	11/23/60	2/ 7/61	ESSA 3	Operational	10/ 2/66	10/19/68
TIROS III	Research	7/12/61	10/30/61	ATS 1	Research	12/ 6/66	—
TIROS IV	Research	2/ 8/62	6/12/62	ESSA 4	Operational	1/26/67	6/19/67
TIROS V	Research	6/19/62	5/ 5/63	ATS 2	Research	4/ 5/67	*
TIROS VI	Research	9/18/62	10/11/63	ESSA 5	Operational	4/20/67	2/20/70
TIROS VII	Research	6/19/63	2/ 3/66	ATS 3	Research	11/ 5/67	—
TIROS VIII	Research	12/21/63	1/22/66	ESSA 6	Operational	11/10/67	11/ 4/69
NIMBUS 1	Research	8/28/64	9/23/64	ESSA 7	Operational	8/16/68	7/19/69
TIROS IX	Research	1/22/65	2/15/67	ESSA 8	Operational	12/15/68	—
TIROS X	Research	7/ 1/65	7/31/66	ESSA 9	Operational	2/26/69	—
ESSA 1	Operational	2/ 3/66	5/ 8/67	NIMBUS 3	Research	4/14/69	9/25/70
ESSA 2	Operational	2/28/66	10/16/70	*Unstable satellite attitude. Data not useful.			

Weather Satellites 1970-

Satellite	Purpose	Launch date	Orbit	Instruments and functions	Remarks
ITOS 1	R/O	1/23/70	Sun Synch. 790 n. mi.	2 AVCS, 2 APT, 2 SR; OMNI, SPM.	Ceased operations June 1971.
Nimbus 4	R	4/ 8/70	Sun Synch. 600 n. mi.	IDCS, THIR; IRIS, SIRS, SCR, FWS; IRLS; BUV, MUSE.	THIR, FWS not operating.
NOAA 1	O	12/11/70	Sun Synch. 790 n. mi.	2 AVCS, 2 APT, 2 SR; OMNI, SPM.	Ceased operations August 1971.
ITOS B	O	10/21/71	Sun Synch. 790 n. mi.	2 AVCS, 2 APT, 2 SR; OMNI, SPM.	Failed to orbit.
ITOS C	O	3/ /72	Sun Synch. 790 n. mi.	2 AVCS, 2 APT, 2 SR; OMNI, SPM.	
ITOS D	O	Summer 72	Sun Synch. 790 n. mi.	2 SR, 2 VHRR; 2 VTPR; OMNI, SPM.	
ITOS E	O		Sun Synch. 790 n. mi.	2 SR, 2 VHRR; 2 VTPR; OMNI, SPM.	Backup to ITOS D.
Nimbus E	R	11/ /72	Sun Synch. 600 n. mi.	THIR, ESMR; ITPR, SCR, MWS; RDR; SCMR.	
SMS A	R/O	12/ /72	Geo. Synch. 19,300 n. mi.	VISSR; DCDR; SEM.	
Nimbus F	R	6/ /74	Sun Synch. 600 n. mi.	THIR, ESMR, TWERLE, HIRS, SCAMS, LRIR, PMR, ERB, TDRE.	

PURPOSE: R—Research
O—Operational
R/O—Operational prototype

INSTRUMENTS AND FUNCTIONS:

APT	—Automatic Picture Transmission	PMR	—Pressure Modulated (carbon dioxide) Radiometer
AVCS	—Advanced Vidicon Camera System (weather satellite)	RDR	—Real-time Data Relay
BUV	—Backscatter Ultraviolet Spectrometer	SCAMS	—Scanning Microwave Spectrometer
DCDR	—Data Collection and Data Relay	SCMR	—Surface Composition Mapping Radiometer
ERB	—Earth Radiation Budget	SCR	—Selective Chopper Radiometer
ESMR	—Electrically Scanning Microwave Radiometer	SEM	—Solar Environment Monitor
FWS	—Filter Wedge Spectrometer	SIRS	—Satellite Infrared Spectrometer
HIRS	—High Resolution Infrared Sounder	SPM	—Solar Proton Monitor
IDCS	—Image Dissector Camera System	SR	—Scanning Radiometer
IRIS	—Infrared Interferometer Spectrometer	TDRE	—Tracking and Data Relay Experiment
IRLS	—Interrogation, Recording, and Location System	THIR	—Temperature-Humidity Infrared Radiometer
ITPR	—Infrared Temperature Profile (multichannel) Radiometer	TWERLE	—Tropical Wind, Energy Conversion, and Reference Level Experiment
LRIR	—Limb Radiance Inversion Radiometer	VHRR	—Very High Resolution Radiometer
MUSE	—Monitor of Ultraviolet Solar Energy	VISSR	—Visual and Infrared Spin-Scan Radiometer
MWS	—Microwave Spectrometer	VTPR	—Vertical Temperature Profile Radiometer
OMNI	—Omnidirectional Radiometers		

Publications

The Federal Coordinator for Meteorological Services and Supporting Research has either prepared, or is in the process of preparing, a series of publications covering the broad spectrum of meteorological programs in the Federal Government. The following is a list of these publications and their status:

The Federal Plan for Meteorological Services and Supporting Research (Published Annually)

World Weather Program Plan (Published Annually)

National East Coast Winter Storms Operations Plan (Revised Annually)

National Hurricane Operations Plan (Revised Annually)

National Severe Local Storms Operations Plan (Revised Annually)

Report of the National Committee for Clear Air Turbulence (December 1966)

Federal Plan for a National Fire-Weather Service (March 1967)

Mesometeorological Research and Development Prospectus (March 1967)

Implementation Plan for the ESSA/USAF Joint-Use Computer Facility at Asheville, N.C. (May 1967)

Federal Plan for Marine Meteorological Services (May 1968)

Planning Guidelines for a Federal Aviation Meteorological Service (August 1968)

The Joint Selection Panel Report on the ESSA/USAF Joint-Use Computer Facility at Asheville, N.C. (January 1969)

Catalog of U.S. Governmental Meteorological Research and Test Facilities (September 1969)

Report on Hurricane Weather Reconnaissance (September 1969)

Federal Plan for Clear Air Turbulence (November 1969)

Federal Plan for Weather Radars and Remote Displays (December 1969) (Under Revision)

Federal Plan for Cooperative Backup Among Operational Processing Centers (August 1970)

Computer Plan for Operational Forecasting and Atmospheric Modeling Research (September 1970)

Federal Plan for Upper Air Observations Above 30 Kilometers (October 1970) (Under Revision)

Federal Plan for Air Pollution Control Meteorological Service (January 1971)

Federal Plan for a National Agricultural Weather Service (January 1971)

National Plan for Rocketsonde Support for Special Events (January 1971)

Federal Plan for Meteorological Data from Satellites (May 1971)

Federal Plan for Climatological Service (Under Development)

Federal Plan on Applied Mesometeorological Research and Development (Under Development)





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